APPENDIX H
LONG-TERM PERFORMANCE ASSESSMENT RESULTS

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A primary focus of the assessment of long-term performance[1] is estimation of human health impacts for the four alternatives proposed for remediation or closure of the site (Sitewide Removal, Sitewide Close-In-Place, Phased Decisionmaking, and No Action). This appendix presents details of the estimates of health impacts for both radiological and hazardous chemical constituents.

The first section of this appendix presents an introduction that first briefly recapitulates the definition of each alternative. The locations and activities associated with each receptor are also described. The second section presents the analysis of the Sitewide Removal Alternative. The third section describes analyses performed for alternatives for which radioactive materials remain onsite – the Sitewide Close-In-Place Alternative and the No Action Alternative. The information is presented in three subsections.

- *Impacts given indefinite continuation of institutional controls*: These impacts take credit for institutional controls to prevent access to the waste management areas, to maintain the integrity of structures such as the Main Plant Process Building, together with engineered features such as erosion control structures and engineered caps. See Section H.2.2.1 for further definition of indefinite continuation of institutional controls.

- *Impacts assuming loss of institutional controls*: In this case it is assumed that institutional controls will be lost after 100 years. (This assumption is conservatively adapted from U.S. Department of Energy (DOE) Manual 435.1-1, which states that for performance assessments prepared by DOE for low-level radioactive waste disposal facilities, "institutional controls shall be assumed to be effective in deterring intrusion for at least 100 years following closure" [DOE 1999]). In particular, it is assumed that there are no more efforts to contain radionuclides and hazardous chemicals within the Main Plant Process Building, the Vitrification Facility, and the Waste Tank Farms. Conservatively, these are assumed to fail as soon as institutional controls fail. This subsection reexamines the analysis for the offsite receptors and also considers failure of institutional controls that would allow intruders to enter the Western New York Nuclear Service Center (WNYNSC) and various waste management areas. See Section H.2.2.2 for further definition of loss of institutional controls.

- *Loss of institutional controls leading to unmitigated erosion*: The offsite receptors are again reanalyzed. In addition, this section considers onsite receptors on the banks of Franks Creek and Erdman Brook who would be exposed to direct radiation shine from eroded surfaces. See Section H.2.2.2.6 for further discussion of unmitigated erosion.

Finally, there is a section that presents the results of sensitivity analyses related to human health impacts.

Note that this appendix is intended only to present the results of the long-term performance assessment. Interpretations, comparisons with regulatory guidelines, and comments on acceptability are provided in Appendix L.

[1] *"Long-term" means until after peak dose or risks have occurred and ranges up to 100,000 years. Note that the analysis assumes that radioactive decay continues to occur throughout this period.*

H.1 Introduction

A set of four alternatives has been proposed to investigate the effects of a range of site closure plans. In addition, a set of potential human receptors has been selected as the basis for estimation of health impacts. The alternatives and receptors are described in the following paragraphs.

H.1.1 The Waste Management Areas

For the convenience of the reader, and to facilitate the discussion of alternatives and receptors, a brief description of the Waste Management Areas (WMAs) is included in **Table H–1** and the locations of WMAs 1-10 are plotted in **Figure H–1**.[2] A detailed description of the WMAs is provided in Appendix C, Section C.2.

Table H–1 Description of Waste Management Areas

Area	*Description*
WMA 1	Main Plant Process Building and Vitrification Area
WMA 2	Low-Level Waste Treatment Facility Area
WMA 3	Waste Tank Farm Area, including High-Level Waste Tanks 8D-1, 8D-2, 8D-3, and 8D-4.
WMA 4	Construction and Demolition Debris Landfill [a]
WMA 5	Waste Storage Area [a]
WMA 6	Central Project Premises [a]
WMA 7	NRC-licensed Disposal Area (NDA) and Associated Facilities
WMA 8	State-licensed Disposal Area (SDA) and Associated Facilities
WMA 9	Radwaste Treatment System Drum Cell [a]
WMA 10	Support and Services Area [a]
WMA 11	Bulk Storage Warehouse and Hydrofracture Test Well Area [a]
WMA 12	Balance of Site [a] (includes steam sediment)
North Plateau Groundwater Plume	A zone of groundwater contamination that extends across WMAs 1, 2, 3, 4, and 5. See Appendix C, Figure C–12, of the EIS.
Cesium Prong	An area of surface soil contamination extending from the Main Plant Process Building in WMA 1 northwest to a distance of 6.0 kilometers (3.7 miles) beyond the boundary of the West Valley Demonstration Project. See Appendix C, Figure C–14, of the EIS.

WMA = Waste Management Area.

[a] These areas do not appear explicitly in any of the results below because they have either already been remediated or do not contain sufficient inventories of radioactive materials or hazardous chemicals to contribute to risks above the noise level.

[2] WMA 11 is not shown in Figure H–1. It contains two self-contained areas in the southeast corner of WNYNSC outside the 84 hectares (200 acres) of the Project Premises and the SDA. And outside the area shown in Figure H–1. WMA 12 is not explicitly shown: it is the balance of the site.

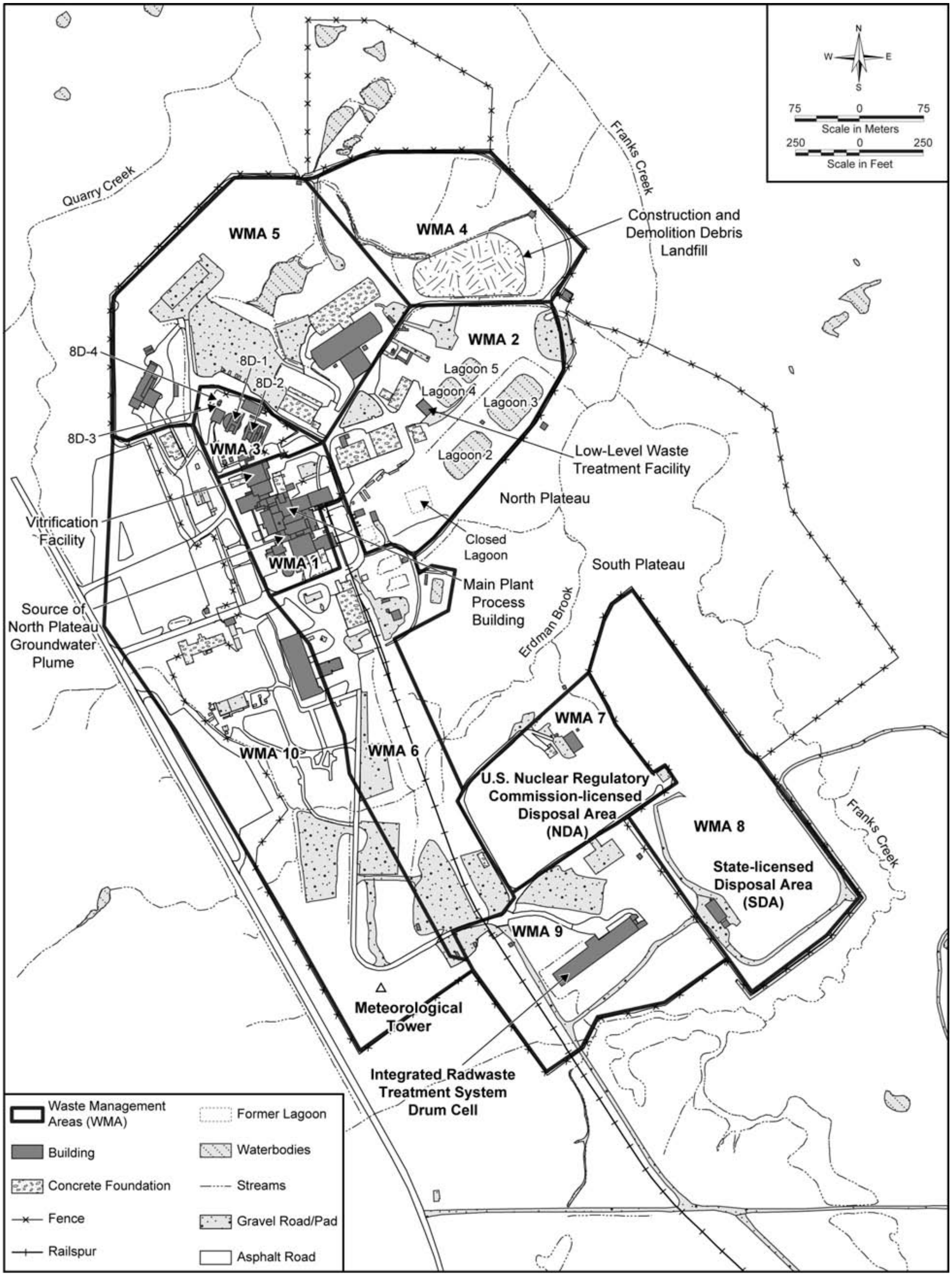

Figure H–1 Location of Waste Management Areas

H.1.2 The Four Alternatives

The alternatives analyzed in this environmental impact statement (EIS) are discussed in detail in Chapter 2 and in Appendix C. In summary, these alternatives are:

- **Sitewide Removal –** all site facilities (see Table 2–2) would be removed. Soils, waters, etc. would be removed or remediated. All radioactive, hazardous, and mixed waste would be characterized, packaged as necessary, and shipped offsite for disposal. The Sitewide Removal Alternative requires temporary onsite storage for the vitrified high-level radioactive waste canisters while waiting for a Federal waste repository to open. Since this alternative is estimated to require approximately 60 years to be completed, it is anticipated that the canisters would be shipped offsite as part of this alternative. The entire WNYNSC would be available for release for unrestricted use. The Sitewide Removal Alternative is one type of bounding alternative that would remove facilities and contamination so that the site could be reused with no restrictions.

  The U.S. Nuclear Regulatory Commission (NRC)-licensed portion of the site would meet the NRC License Termination Rule (10 *Code of Federal Regulations* [CFR] 20.1402). The State-licensed portion of the site (the SDA) would meet similar State criteria. Residual hazardous contaminants would meet applicable State and Federal standards. A final status survey performed in accordance with Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM) and the Resource Conservation and Recovery Act (RCRA) guidance would demonstrate that the remediated site meets the standards for unrestricted release, which would be confirmed by independent verification surveys.

- **Sitewide Close-In-Place –** key site facilities (see Table 2–2 and Section 2.4.1.1) would be closed in place. The residual radioactivity in facilities with larger inventories of long-lived radionuclides would be isolated by specially-designed closure structures and engineered barriers. The Sitewide Close-In-Place Alternative is another type of bounding alternative where the major facilities and sources of contamination would be managed at its current location.

- **Phased Decisionmaking (Preferred Alternative) –** the decommissioning would be completed in two phases:

  – Phase 1 decisions would include removal of all WMA 1 facilities (Main Plant Process Building, Vitrification Facility, and 01-14 Building), the lagoons in WMA 2, and the source area of the North Plateau Groundwater Plume. No decommissioning or long-term management decisions would be made for the Waste Tank Farm and its support facilities, the Construction and Demolition Debris Landfill (CDDL), the nonsource area of the North Plateau Groundwater Plume, or the NRC-licensed Disposal Area (NDA). The State-licensed Disposal Area (SDA) would continue under active management consistent with its New York State Department of Health (NYSDOH) license and a New York State Department of Environmental Conservation (NYSDEC) permit for up to 30 years. Phase 1 activities would also include additional characterization of site contamination and studies to provide information to support additional evaluations to determine the approach to be used to complete the decommissioning.

  – Phase 2 would complete the decommissioning or long-term management decisionmaking, following the approach determined through the additional evaluations to be the most appropriate.

- **No Action—**no actions toward decommissioning would be taken. The No Action Alternative would involve the continued management and oversight of the remaining portion of the WNYNSC and all facilities located on the WNYNSC property as of the starting point of this EIS.

Table H–2 summarizes the important features of the alternatives that are analyzed in the EIS.

H.1.3 The Receptors

The approach used for estimation of health impacts is development and analysis of a set of scenarios comprising sources of hazardous material, facility closure designs, environmental transport pathways, and human receptor locations and activities. A detailed description of this approach is presented in Appendix D. This section summarizes the selection of receptors, and describes the locations and activities that are the primary attributes contributing to potential impacts on receptors.

H.1.3.1 Summary List – Receptor Locations

Receptor locations are selected based on comparison of environmental transport pathways, current demography, and regulatory guidance. Receptor locations considered in the analysis include those located outside the boundaries of the WNYNSC (offsite) and those located within the boundaries proposed for control under a given alternative (onsite). The reasons for the choice of receptors are given in Appendix D, Section D.3.1.3, which also contains a more detailed description of those receptors than does the summary below. Table D–4 contains a summary of receptor exposure modes. Offsite receptors would be affected for both assumed continuation of institutional controls and assumed loss of institutional controls. Onsite receptors are considered under assumed loss of institutional controls. Offsite receptor locations are:

- Cattaraugus Creek – just downstream of Franks Creek
- Cattaraugus Creek – Seneca Nation of Indians Cattaraugus Reservation
- Drinkers of water from municipal water system intakes at Sturgeon Point near Derby, New York and in the Niagara River. These receptors do not necessarily live on the shores of Lake Erie or the Niagara River.

The locations of offsite receptors and one onsite receptor (Buttermilk Creek) are shown in **Figure H–2**.

Onsite receptor locations are selected based on the location of existing contamination in the environment, the location and function of engineered barriers for closure systems, and regulatory guidance. Locations selected for the North and South Plateaus include:

- Onsite North Plateau
  - Main Plant Process Building (WMA 1)
  - Vitrification Facility (WMA 1)
  - Low-Level Waste Treatment Facility (WMA 2)
  - Waste Tank Farm (WMA 3)
  - North Plateau Groundwater Plume
  - Cesium Prong

Table H–2 Summary of Alternatives

	Sitewide Removal	*Sitewide Close-In-Place*	*Phased Decisionmaking Phase 1 Activities (up to 30 years)* [a]	*No Action*
Canisters	Storage in new Interim Storage Facility until they can be shipped offsite	Storage in new Interim Storage Facility until they can be shipped offsite.	Storage in new Interim Storage Facility until they can be shipped offsite	No decommissioning action
Process Building	Decontamination, demolition without containment and removal from site	Decontamination, demolition without containment. Rubble used to backfill underground portions of the Main Plant Process Building and Vitrification Facility, and to form the foundation of a cap.	Decontamination, demolition without containment and removal from site	No decommissioning action
High-Level Waste Tanks	Removal, including associated contaminated soil and groundwater in WMA 3	Backfilled with controlled, low-strength material. Strong grout placed between the tank tops and in the tank risers. Underground piping to remain in place and filled with grout. Closed in an integrated manner with the Main Plant Process Building, Vitrification Facility, and North Plateau Groundwater Plume source with a common circumferential hydraulic barrier and beneath a common multi-layer cap.	Remain in-place, monitored and maintained with the Tank and Vault Drying system operating as necessary	No decommissioning action
NRC-licensed Disposal Area (NDA)	Removal	Removal offsite of liquid pretreatment system. Trenches, and holes emptied of leachate and grouted. Buried leachate transfer line to remain in place. Existing NDA geomembrane cover replaced with a robust multi-layer cap.	Continued monitoring and maintenance	No decommissioning action
State-licensed Disposal Area (SDA)	Removal	Leachate removed from disposal trenches and replaced with grout. Waste Storage Facility removed to grade. Existing SDA geomembrane cover replaced with robust multi-layer cap. Hydraulic barrier installed.	Active management for up to 30 years	No decommissioning action
North Plateau Groundwater Plume	Removal	Plume source area closed in an integrated manner with the Main Plant Process Building, Vitrification Facility and Waste Tank Farm within a common circumferential barrier. Permeable treatment wall installed before decommissioning would remain in place. Nonsource area allowed to decay in place.	Removal of source area	No decommissioning action
Cesium Prong	Removal	Restrictions on use until sufficient decay has taken place.	Managed in place	No decommissioning action

WMA = Waste Management Area.

[a] Up to 30 years is the period for all Phase 1 activities. Decommissioning activities will be completed within 8 years.

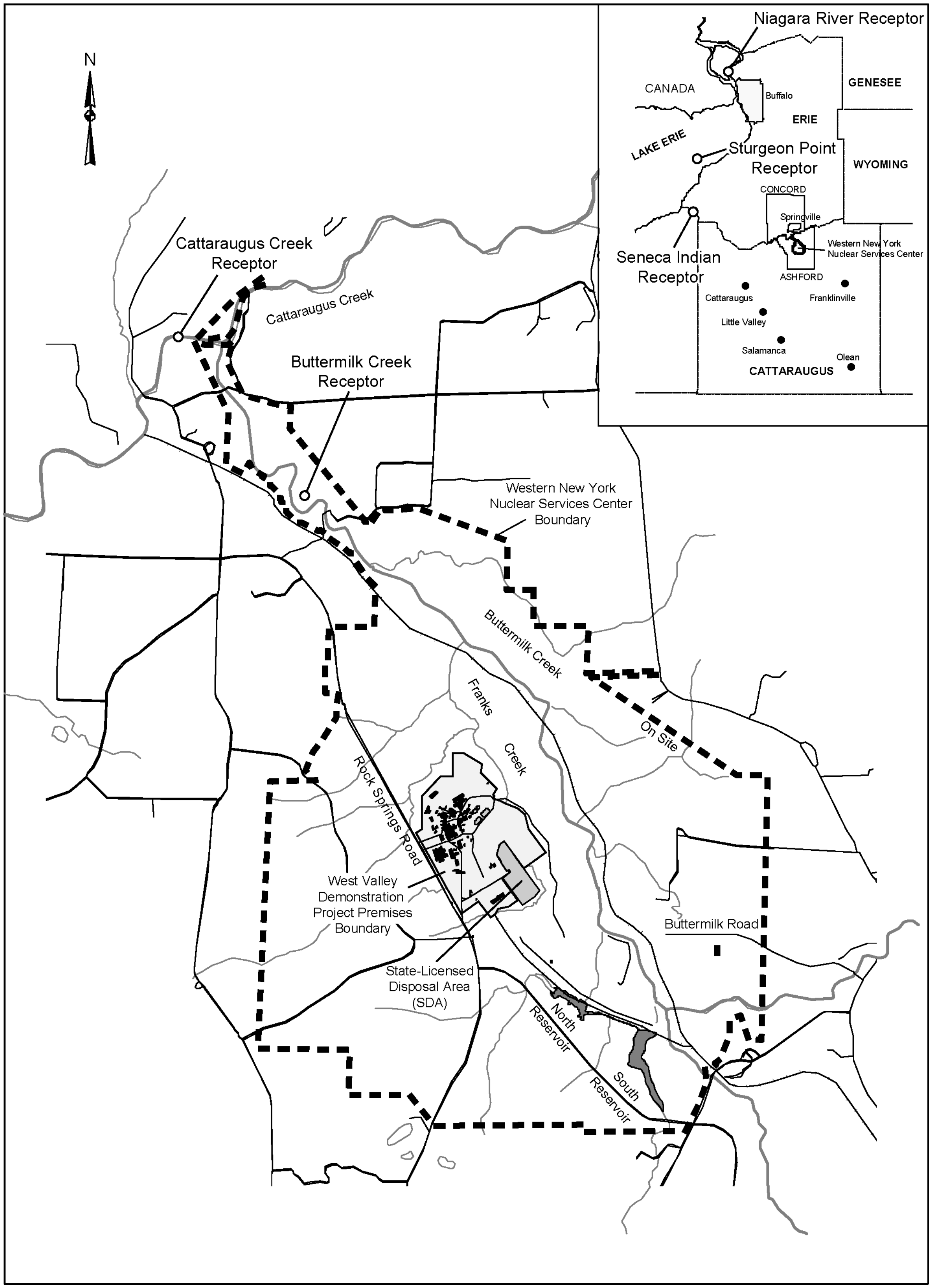

Figure H–2 Location of Offsite Receptors and Buttermilk Creek Receptor

- Onsite South Plateau
  - NDA (WMA 7)
  - SDA (WMA 8)
- Onsite adjacent to Buttermilk Creek.[3]
- On the East bank of Franks Creek opposite the SDA, on the West bank of Erdman Brook opposite the NDA, and in the area of the Low-Level Waste Treatment Facility (receptors for the erosion analysis)

Figure H–3 shows the locations of the receptors for the erosion analysis. It also shows the assumed location of wells that are used in subsequent calculations involving the use or consumption of contaminated groundwater.

Table H–3 Values of Parameters for the Home Construction Scenario

Parameter	*Value*	*Source*
Excavation Length and Width	23 meters	Oztunali and Roles 1986
Excavation Depth	3 meters	Oztunali and Roles 1986
Dust Mass Loading for Inhalation	0.538 milligrams per cubic meters	Beyeler et al. 1999
Duration of Construction Work	500 hours	Oztunali and Roles 1986
Inhalation Rate	8,400 cubic meters per year	Beyeler et al. 1999

H.1.3.2 Types of Receptors

Types of receptors selected to provide a basis for EIS analysis are individuals involved in home construction, well drilling, recreational hiking, maintaining a home and garden (resident farmer), and a non-farming resident. In the cases of home construction and well drilling the receptors are workers directly contacting contaminated material during activities that intrude into the waste.

For *home construction*, worker exposure pathways include inadvertent ingestion of contaminated soil, inhalation of contaminated dust, and exposure to external radiation from the walls of an excavation for the foundation of a home. Assumed locations for home construction are directly on top of facilities such as the Main Plant Process Building, Vitrification Facility, lagoons, Waste Tank Farm, or within areas such as the NDA and SDA for the No Action Alternative (see Figure H–1). Values of parameters for the home construction worker receptor and scenario are summarized in Table H–3.

For *well drilling*, worker exposure pathways include inadvertent ingestion of contaminated soil, inhalation of contaminated dust, and direct exposure to external radiation from contaminated water in a cuttings pond. Assumed locations for well drilling are directly on top of facilities such as the Main Plant Process Building, Vitrification Facility, lagoons, Waste Tank Farm, or within areas such as the NDA and SDA for the No Action Alternative and the Low-Level Waste Treatment Facility for the Sitewide Close-In-Place Alternative (see Figure H–1). Values of parameters characterizing this receptor and scenario are summarized in **Table H–4**. Because all waste at the West Valley Site is within thirty meters of the ground surface, depth to waste is not a constraint that limits occurrence of the well-drilling scenario.

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[3] *This receptor is located below the Franks Creek discharge into Buttermilk Creek and above the Buttermilk Creek discharge into Cattaraugus Creek. The predicted radiation dose to such as receptor would be the same anywhere along this entire length because there is very little dilution of the flow until Cattaraugus Creek is reached.*

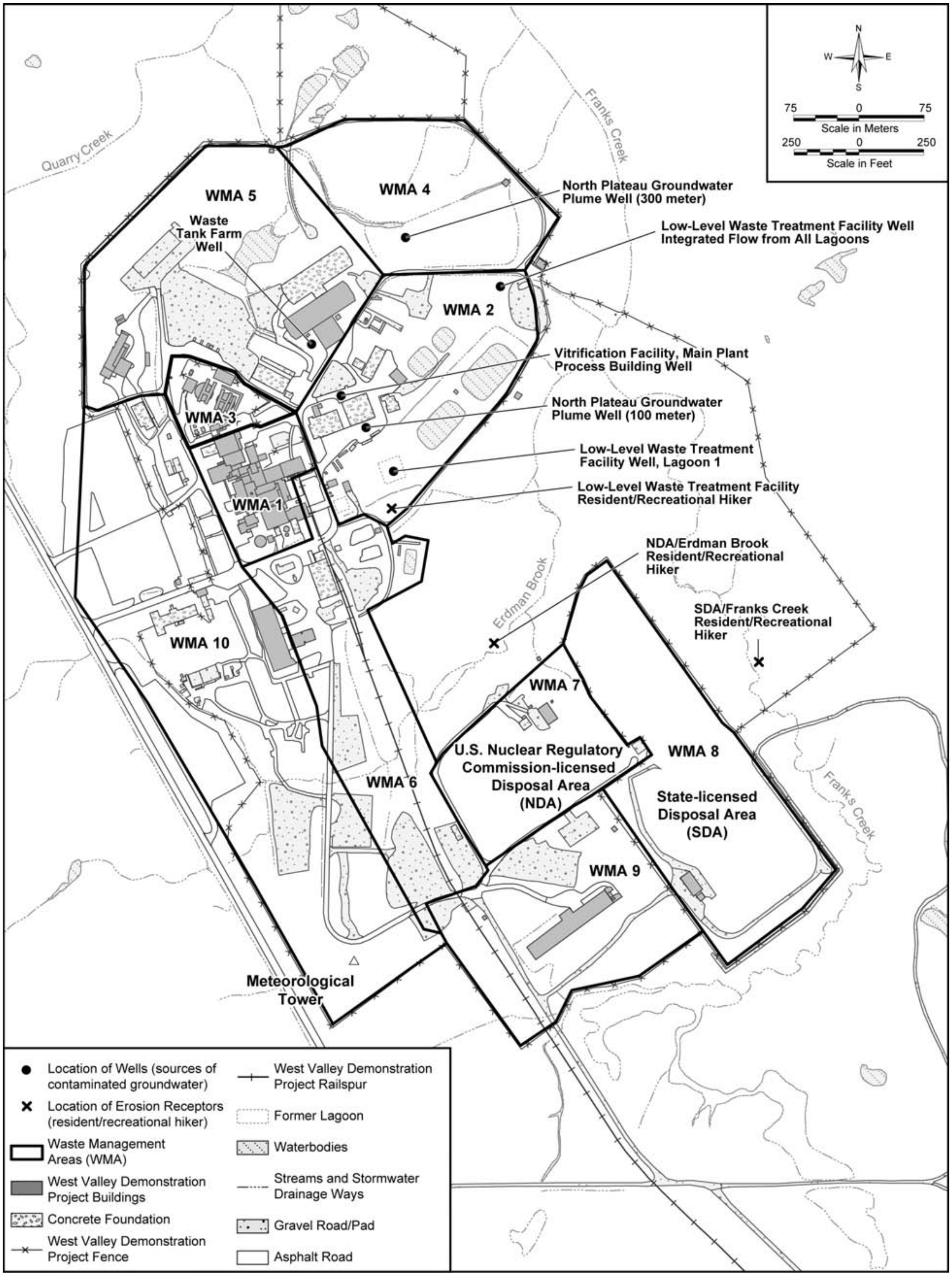

Figure H–3 Location of Wells and Resident/Recreational Hikers

Table H–4 Values of Parameters for the Well Drilling Scenario

Parameter	*Value*	*Source*
Drill Hole Diameter	20 centimeters	Oztunali and Roles 1986
Maximum Hole Depth	61 meters	Oztunali and Roles 1986
Well Completion Time	6 hours	Oztunali and Roles 1986
Cuttings Pond Length	2.7 meters	Oztunali and Roles 1986
Cuttings Pond Width	2.4 meters	Oztunali and Roles 1986
Cuttings Pond Depth	1.2 meters	Oztunali and Roles 1986
Cuttings Pond Water Shielding Layer Depth	0.6 meters [a]	Oztunali and Roles 1986
Inhalation Rate	8,400 cubic meters per year	Beyeler et al. 1999

[a] The analysis takes credit for the shielding provided by a 2-foot (0.6-meter) layer of water, consistent with the discussion of this scenario in NUREG/CR-4370 (Oztunali and Roles 1986).

Exposure modes for *recreational hiking* are inadvertent ingestion of soil and inhalation of fugitive dust for both radionuclides and hazardous chemicals and exposure to direct radiation for radionuclides. For radionuclides, values of parameters for these pathways are summarized in Tables H–9 and H–10. For hazardous chemicals, values of parameters are those presented in Table H–15 for the inadvertent soil ingestion and inhalation of fugitive dust pathways. For both radionuclides and hazardous chemicals, exposure time for recreational hiking is determined by time spent in the contaminated area. Parameters determining exposure time for the recreational hiker exposure pathway are length of the contaminated area, rate of hiking through the area, and frequency and duration of exposure. Values for these parameters are summarized in **Table H–5**. These parameters are based on the known dimensions of the Process Building, high-level waste tanks, SDA, and NDA. Exposure modes for a hiker include inadvertent ingestion of soil, inhalation of fugitive dust, and exposure to direct radiation. Exposure through recreational hiking pathways is evaluated for onsite receptors for both groundwater and erosion-release scenarios. Results for erosion-release scenarios are presented in Table H–62 and associated text, where hiking along an active erosion front is considered to be the bounding scenario. This EIS does not analyze the less conservative scenario of a downstream hiker coming into contact with contaminated creek-bank sediments. For groundwater release scenarios, exposure through the recreational hiking pathways contributes a small fraction of the total impact. The method for calculating the dose for the recreational hiking pathways is described in Appendix G, Section G.4.2.4.

Table H–5 Values of Parameters for Exposure Time in Recreational Hiking

Parameter	*Value*	*Source*
Length of Contaminated Area		
Process Building	10 to 40 meters	Site Specific
Vitrification Facility	7 to 10 meters	Site Specific
High-level waste tanks 8D-1 and 8D-2	30 meters	Site Specific
High-level waste tanks 8D-3 and 8D-4	6 meters	Site Specific
NDA	60 meters	Site Specific
SDA	400 meters	Site Specific
Velocity of hiking	1.6 kilometers per hour	A conservative hiking speed of 1.6 kilometers (approximately 1 mile) per hour
Exposure frequency	365 days per year	EPA 1999
Exposure duration	30 years	EPA 1999

NDA = NRC-licensed Disposal Area, SDA = State-licensed Disposal Area.

Exposure pathways for the *resident farmer* are based on contact with surface soil and involves a set of activities including living in a home, maintaining a garden, harvesting fish and deer, and recreational hiking. The scenario may be initiated by existing residual contamination of surface soil, by irrigation with contaminated groundwater or surface water, by deposition of contaminated soil from the home construction excavation on the ground surface, by deposition of contaminated soil from the well drilling cuttings pond on the ground surface, or by exposure of contaminated material during erosion. The locations of wells that could potentially supply contaminated groundwater are shown in Figure H–3. The locations of the farmer's gardens are not explicitly located in Figure H–3. It is simply assumed that those gardens are somewhere nearby and that they are contaminated by water piped from one of the wells or by contaminated waste deposited after home construction or well drilling.

For both radionuclides and hazardous chemicals, maintenance of a home and garden involves inadvertent ingestion of soil, inhalation of fugitive dust, and consumption of crops and animal products. For radionuclides, there is an additional pathway, exposure to external radiation.

The location and mode of transport of contaminated material and the nature and location of the receptor determine the degree of exposure to each of the exposure pathways of the resident farmer scenario. General assumptions connecting exposure modes and receptor locations and activities are:

- Exposure pathways related to maintenance of a home and garden apply to both onsite and offsite receptors.

- When surface soil is contaminated by irrigation with groundwater or surface water, exposure by drinking water involves consumption of the primary source of groundwater or surface water rather than by consumption of water infiltrating through the contaminated soil. The pathways other than consumption of drinking water are termed water independent pathways.

- When the source of contamination is residue on surface soil rather than irrigation water, infiltration through the soil is the source of drinking water. The combined pathways are termed water dependent pathways.

- Consumption of fish occurs for the Buttermilk Creek onsite receptor and for offsite receptors.

- Discharge of contaminated groundwater to surface water contaminates soils and plants along onsite creek banks, initiating the deer consumption and recreational hiking pathways. Therefore, these two pathways apply for onsite receptors.

Because human health impacts related to radionuclides and hazardous chemicals involve differing physiological mechanisms, differing sets of parameters characterize receptors for these two classes of materials. Sets of parameters used to estimate health impact due to exposure to radionuclides during residence in a home and maintenance of a garden are presented in **Tables H–6 through H–11** and the exposure pathways for residing in a home and maintaining a garden are summarized in **Table H–12**. Unit dose and risk factors for these pathways, calculated using the RESRAD, Version 6.1 computer code (Yu et al. 1993) are presented in **Tables H–13** and **H–14** for the water dependent and water independent pathways, respectively.

Table H–6 Data Values for Residential and Garden Exposure Pathways for Radionuclides on the North and South Plateaus: Contaminated Zone Data

Parameter	*Parameter Value* [a]	*Source*
Area	6,850 square meters	NUREG/CR-5512 [b]
Thickness	1 meter	Site specific
Length parallel to aquifer flow	85 meters	Site specific
Bulk density	1.7 grams per cubic meter	WVNS 1993d, 1993c
Erosion rate	1×10^{-5} meters per year	WVNS 1993a
Total porosity	0.36 (for both North and South Plateaus)	WVNS 1993c
Field Capacity	0.20	WVNS 1993c
Hydraulic conductivity	3,500 meters per year (North Plateau) 0.01 meters per year (South Plateau)	WVNS 1993b
b Parameter [c]	1.4	NUREG/CR-5512 [b]
Evapotranspiration coefficient	0.78	WVNS 1993c
Wind speed	2.6 meters per second	WVNS 1993c
Precipitation	1.16 meters per year	WVNS 1993e
Irrigation rate	0.47 meters per year (water dependent) 0.0 meters per year (water independent)	NUREG/CR-5512 [d]
Irrigation mode	Overhead	Site specific
Runoff coefficient	0.41	WVNS 1993c

[a] Parameter values are the same for the North and South plateaus with the exception of total porosity and hydraulic conductivity.
[b] NUREG/CR-5512, Vol. 3 (Beyeler et al. 1999).
[c] Value for loamy sand (based onsite conditions).
[d] The authors have been unable to find a referenceable basis for site-specific irrigation rates.

Table H–7 Data Values for Residential and Garden Exposure Pathways for Radionuclides on the North and South Plateaus: Saturated Zone Hydrologic Data

Parameter	*Parameter Value* [a]	*Source*
Bulk density	1.7 grams per cubic meter	WVNS 1993d, 1993c
Total porosity	0.36 (for both North and South Plateaus)	WVNS 1993c
Field capacity	0.20	WVNS 1993c
Effective porosity	0.25	WVNS 1993c
Hydraulic conductivity	3,500 meters per year (North Plateau) 0.01 meters per year (South Plateau)	WVNS 1993b
Hydraulic gradient	0.03	WVNS 1993b
Water table drop rate	0 meters per year	Site Specific
Well pump intake depth	2 meters (below water table)	Site specific
Mixing model	Non-dispersion	Site specific
Well pumping rate	3,300 cubic meters per year (water dependent) 0 cubic meters per year (water independent)	NUREG/CR-5512 [b, c]

[a] Parameter values are the same for the North and South plateaus with the exception of total porosity and hydraulic conductivity.
[b] NUREG/CR-5512, Vol. 3 (Beyeler et al. 1999).
[c] Sum of domestic use and irrigation rate.

Table H–8 Data Values for Residential and Garden Exposure Pathways for Radionuclides on the North and South Plateaus: Uncontaminated and Unsaturated Zone Hydrologic Data

Parameter	*Parameter Value* [a]	*Source*
Number of strata	1	Site specific
Thickness	2 meters	Site specific
Bulk density	1.7 grams per cubic meter	WVNS 1993d, 1993c
Total porosity	0.36 (for both North and South Plateaus)	WVNS 1993c
Effective porosity	0.25	WVNS 1993c
Hydraulic conductivity	3,500 meters per year (North Plateau) 0.01 meters per year (South Plateau)	WVNS 1993b
b Parameter [b]	1.4	NUREG/CR-5512 [c]

[a] Parameter values are the same for the North and South plateaus with the exception of total porosity and hydraulic conductivity.
[b] Value for loamy sand (based onsite conditions).
[c] NUREG/CR-5512, Vol. 3 (Beyeler et al. 1999).

Table H–9 Data Values for Residential and Garden Exposure Pathways for Radionuclides: Dust Inhalation and External Gamma Data

Parameter	*Parameter Value*	*Source*
Inhalation rate	8,400 cubic meters per year	NUREG/CR-5512 [a]
Mass loading for inhalation	4.5×10^{-6} grams per cubic meter	NUREG/CR-5512 [b]
Exposure duration	1 year	NUREG/CR-5512
Indoor dust filtration factor	1	NUREG/CR-5512
Shielding factor, external gamma	0.59	NUREG/CR-5512 [c]
Fraction of time indoors, onsite	0.66	NUREG/CR-5512
Fraction of time outdoors, onsite	0.12	NUREG/CR-5512
Shape factor, external gamma	1	RESRAD [d]

[a] NUREG/CR-5512, Vol 3 (Beyeler et al. 1999).
[b] Activity and time average of NUREG/CR-5512 values.
[c] Sum of products of the means of the fraction of time and shielding factors for indoor and outdoor exposure.
[d] RESRAD (Yu et al. 1993).

Table H–10 Data Values for Residential and Garden Exposure Pathways for Radionuclides: Dietary Data

Parameter	*Parameter Value*	*Source*
Fruit, vegetable and grain consumption rate	112 kilograms per year	NUREG/CR-5512 [a, b]
Leafy vegetable consumption rate	21 kilograms per year	NUREG/CR-5512
Milk consumption	233 liters per year	NUREG/CR-5512
Meat and poultry consumption	65 kilograms per year	NUREG/CR-5512 [c]
Soil ingestion rate	43.8 grams per year	EPA/540-R-00-007 [d] NUREG/CR-5512
Drinking water intake rate	730 liters per year (water dependent) 0 liters per year (water independent)	NUREG/CR-5512
Fraction contaminated drinking water	1	NUREG/CR-5512
Fraction contaminated livestock water	1	NUREG/CR-5512
Fraction contaminated irrigation water	1	NUREG/CR-5512
Fraction contaminated plant food	1	NUREG/CR-5512
Fraction contaminated meat	1	NUREG/CR-5512
Fraction contaminated milk	1	NUREG/CR-5512

[a] NUREG/CR-5512, Vol 3 (Beyeler et al. 1999).
[b] Sum of individual means for other vegetables, fruit and grain.
[c] Sum of individual means for meat and poultry.
[d] Soil Screening Guidance for Radionuclides.

Table H–11 Data Values for Residential and Garden Exposure Pathways for Radionuclides: Nondietary Data, North Plateau

Parameter	*Parameter Value*	*Source*
Livestock fodder intake for meat	27.3 kilograms per day	NUREG/CR-5512 [a]
Livestock fodder intake for milk	64.2 kilograms per day	NUREG/CR-5512 [b]
Livestock water intake for meat	50 liters per day	NUREG/CR-5512
Livestock water intake for milk	60 liters per day	NUREG/CR-5512
Livestock intake of soil	0.5 kilograms per day	RESRAD [c]
Mass loading for foliar deposition	4×10^{-4} grams per cubic meter	NUREG/CR-5512 [d]
Depth of soil mixing layer	0.15 meters	NUREG/CR-5512
Depth of roots	0.9 meters	RESRAD
Fraction of drinking water from groundwater	1	NUREG/CR-5512
Fraction of livestock water from groundwater	1	NUREG/CR-5512
Fraction of irrigation water from groundwater	1	NUREG/CR-5512

[a] NUREG/CR-5512, Vol 3 (Beyeler et al. 1999).
[b] Sum of individual medians for forage, hay and grain.
[c] Default parameter value from RESRAD (Yu et al. 1993).
[d] Value for gardening.

Table H–12 Summary of Exposure Modes for Residential and Garden Exposure to Radionuclides

Exposure Mode	*Water-Dependent Pathways*	*Water-Independent Pathways*
External gamma	Active	Active
Inhalation	Active	Active
Plant ingestion	Active	Active
Meat ingestion	Active	Active
Milk ingestion	Active	Active
Drinking water ingestion	Active	Inactive
Soil ingestion	Active	Active

Table H–13 RESRAD Unit Dose Factors for Water-Dependent Pathways

Nuclide	*Distribution Coefficient* [a] *(milliliters per gram)*	*Unit Dose Factor [(rem per year / (picocuries per gram)]*	*Unit Risk Factor (1 per year)*
Tritium	1	2.4×10^{-5}	2.2×10^{-8}
Carbon-14	20.9	1.1×10^{-3}	9.4×10^{-7}
Cobalt-60	1,000	7.4×10^{-3}	5.9×10^{-6}
Nickel-63	37.2	1.4×10^{-5}	2.3×10^{-8}
Selenium-79	115	5.4×10^{-4}	4.9×10^{-7}
Strontium-90	5	6.0×10^{-3}	5.0×10^{-6}
Technetium-99	7.4	1.7×10^{-3}	3.0×10^{-6}
Antimony-125	174	1.0×10^{-3}	7.6×10^{-7}
Iodine-129	4.6	1.5×10^{-2}	2.3×10^{-6}
Cesium-137	447	2.3×10^{-3}	1.7×10^{-6}
Promethium-147	5,010	4.0×10^{-7}	9.8×10^{-10}
Samarium-151	993	1.6×10^{-7}	3.6×10^{-10}
Europium-154	955	3.5×10^{-3}	2.7×10^{-6}
Lead-210	2,400	1.0×10^{-2}	5.0×10^{-6}
Radium-226	3,550	2.1×10^{-2}	1.2×10^{-5}
Radium-228	3,550	1.8×10^{-2}	1.1×10^{-5}
Actinium-227	1,740	2.6×10^{-3}	9.3×10^{-7}
Thorium-228	5,890	4.1×10^{-3}	3.2×10^{-6}
Thorium-229	5,890	1.2×10^{-3}	6.8×10^{-7}
Thorium-230	5,890	1.7×10^{-2}	9.1×10^{-6}
Thorium-232	5,890	2.4×10^{-2}	1.5×10^{-5}
Protactinium-231	2,040	6.9×10^{-3}	1.4×10^{-6}
Uranium-232	10	4.5×10^{-3}	3.2×10^{-6}
Uranium-233	10	1.7×10^{-3}	5.6×10^{-7}
Uranium-234	10	1.6×10^{-3}	5.5×10^{-7}
Uranium-235	10	1.7×10^{-3}	6.1×10^{-7}
Uranium-236	10	1.6×10^{-3}	5.2×10^{-7}
Uranium-238	10	1.6×10^{-3}	7.0×10^{-7}
Neptunium-237	7.1	5.3×10^{-3}	6.3×10^{-7}
Plutonium-238	955	1.5×10^{-4}	2.9×10^{-8}
Plutonium-239	955	1.6×10^{-4}	3.0×10^{-8}
Plutonium-240	955	1.6×10^{-4}	3.0×10^{-8}
Plutonium-241	955	4.5×10^{-6}	1.1×10^{-9}
Americium-241	1,450	1.5×10^{-4}	3.6×10^{-8}
Curium-243	6,760	3.7×10^{-4}	2.2×10^{-7}
Curium-244	6,760	7.5×10^{-5}	1.8×10^{-8}

[a] Site-specific data for strontium and uranium (Dames and Moore 1995a, 1995b), balance of data from NUREG/CR-5512, Vol. 3 (Beyeler et al. 1999).

Table H–14 RESRAD Unit Dose Factors for Water-Independent Pathways

Nuclide	***Distribution Coefficient*** [a] ***(milliliters per gram)***	***Unit Dose Factor [(rem per year)/ (picocuries per gram)]***	***Unit Risk Factor (1 per year)***
Tritium	1	4.2×10^{-6}	3.9×10^{-8}
Carbon-14	20.9	1.1×10^{-3}	9.4×10^{-7}
Cobalt-60	1,000	7.4×10^{-3}	5.9×10^{-6}
Nickel-63	37.2	1.4×10^{-5}	2.3×10^{-8}
Selenium-79	115	5.4×10^{-4}	4.9×10^{-7}
Strontium-90	5	6.0×10^{-3}	5.0×10^{-6}
Technetium-99	7.4	1.8×10^{-3}	3.0×10^{-6}
Antimony-125	174	1.0×10^{-3}	7.6×10^{-7}
Iodine-129	4.6	3.0×10^{-3}	2.4×10^{-6}
Cesium-137	447	2.3×10^{-3}	1.7×10^{-6}
Promethium-147	5,010	4.0×10^{-7}	9.8×10^{-10}
Samarium-151	993	1.6×10^{-7}	3.6×10^{-10}
Europium-154	955	3.5×10^{-3}	2.7×10^{-6}
Lead-210	2,400	1.0×10^{-2}	5.0×10^{-6}
Radium-226	3,550	2.1×10^{-2}	1.2×10^{-5}
Radium-228	3,550	1.8×10^{-2}	1.1×10^{-5}
Actinium-227	1,740	2.6×10^{-3}	9.3×10^{-7}
Thorium-228	5,890	4.1×10^{-3}	3.2×10^{-6}
Thorium-229	5,890	1.2×10^{-3}	6.8×10^{-7}
Thorium-230	5,890	7.7×10^{-3}	4.2×10^{-6}
Thorium-232	5,890	2.4×10^{-2}	1.5×10^{-5}
Protactinium-231	2,040	6.9×10^{-3}	1.4×10^{-6}
Uranium-232	10	4.6×10^{-3}	3.3×10^{-6}
Uranium-233	10	9.0×10^{-5}	4.6×10^{-8}
Uranium-234	10	8.6×10^{-5}	4.5×10^{-8}
Uranium-235	10	4.4×10^{-4}	3.1×10^{-7}
Uranium-236	10	8.2×10^{-5}	4.3×10^{-8}
Uranium-238	10	1.5×10^{-4}	1.1×10^{-7}
Neptunium-237	7.1	1.7×10^{-3}	6.3×10^{-7}
Plutonium-238	955	1.5×10^{-4}	3.3×10^{-8}
Plutonium-239	955	1.6×10^{-4}	3.0×10^{-8}
Plutonium-240	955	1.6×10^{-4}	3.0×10^{-8}
Plutonium-241	955	4.5×10^{-6}	4.2×10^{-10}
Americium-241	1,450	1.5×10^{-4}	3.6×10^{-8}
Curium-243	6,760	3.7×10^{-4}	2.2×10^{-7}
Curium-244	6,760	7.5×10^{-5}	1.8×10^{-8}

[a] Site-specific data for strontium and uranium (Dames and Moore 1995a, 1995b), balance of data from NUREG/CR-5512, Vol. 3 (Beyeler et al. 1999).

Table H–15 Values of Parameters for Exposure to Hazardous Chemicals

Parameter	*Value*	*Source*
Drinking Water Ingestion		
Ingestion Rate	2.35 liters per day	EPA/600/C-99/001
Exposure Frequency	365 days per year	EPA/600/C-99/001
Exposure Duration	30 years	EPA/600/C-99/001
Inadvertent Soil Ingestion		
Ingestion Rate	120 milligrams per day	EPA/540-R-00-007
Exposure Frequency	365 days per year	EPA/540-R-00-007
Exposure Duration	30 year	EPA/540-R-00-007
Fugitive Dust Inhalation		
Particulate emission factor	1.32×10^9 cubic meters per kilogram	EPA/540-R-00-007
Inhalation Rate	20 cubic meters per day	EPA/540-R-00-007
Exposure Frequency	365 days per year	EPA/540-R-00-007
Exposure Duration	30 years	EPA/540-R-00-007
Outdoor exposure time fraction	0.073	EPA/540-R-00-007
Indoor exposure time fraction	0.683	EPA/540-R-00-007
Dilution factor for indoor inhalation	0.4	EPA/540-R-00-007
Crop Ingestion		
Vegetable and fruit ingestion rate	112 kilograms per year	NUREG/CR-5512
Leafy vegetables ingestion rate	21 kilograms per year	NUREG/CR-5512
Exposure duration	30 years	EPA/540-R-00-007
Meat Ingestion		
Ingestion Rate	65 kilograms per year	NUREG/CR-5512
Exposure Duration	30 years	EPA/600/C-99/001
Milk Ingestion		
Ingestion Rate	233 liters per year	NUREG/CR-5512
Exposure Duration	30 years	EPA/600/C-99/001

The degree of contamination for the deer consumption pathway involves consideration of the portion of deer diet obtained in the contaminated area and the amount of deer meat consumed. Values for these parameters are presented in **Table H–16**. The amount of deer consumed (65 kilograms per year) is the difference between the 95th percentile estimate for meat consumption during a year (EPA 1999) and the estimate of home production meat and poultry (Beyeler et al. 1999) used in the RESRAD simulation of the residential and garden pathways. Note that in practice the deer pathway contributes only a very small fraction of predicted doses.

Table H–16 Values for the Deer Ingestion Pathway

Parameter	*Value*	*Source*
Ingestion Rate	65 kilograms per year	EPA 1999, Beyeler et al. 1999
Length of Contaminated Area		
Process Building	10 to 40 meters	Site Specific
Vitrification Facility	7 to 10 meters	Site Specific
High-level waste tanks 8D-1 and 8D-2	30 meters	Site Specific
High-level waste tanks 8D-3 and 8D-4	6 meters	Site Specific
NDA	60 meters	Site Specific
SDA	400 meters	Site Specific
Deer range area	2.5 square kilometers	State of Missouri 2004
Deer rate of consumption of vegetation	2.25 kilograms per day	State of North Carolina 2004
Exposure frequency	365 days per year	EPA 1999
Exposure duration	30 years	EPA 1999

NDA = NRC-licensed Disposal Area, SDA = State-licensed Disposal Area.

In addition to the residential and garden exposure pathways, offsite receptors may harvest fish from surface water downstream of the WNYNSC. Exposure pathways data for offsite receptors are summarized in **Table H–17**.

Table H–17 Exposure Pathway Data for Offsite Receptors [a]

Receptor Location	*Scenario*	*Consumption of Drinking water (liters per day)*	*Consumption of Impacted Fish (kilograms per year)*	*Use of Water for Garden Irrigation*
Cattaraugus Creek, downstream of confluence with Buttermilk Creek	Resident farmer	2.35 [b]	9.0 [b]	Yes
Cattaraugus Creek at Seneca Nation of Indian reservation	Resident farmer	2.35	62.0 [b]	Yes
Sturgeon Point water user	Drinking water user, fish consumer	2.35	0.1 [c]	Yes
Niagara River water user	Drinking water user, fish consumer	2.35	0.1 [c]	Yes

[a] In the long-term performance assessment, offsite receptors are not exposed via the deer pathway or as recreational hikers. This is not because the predicted radiation dose from such activities is exactly zero. It is because, if calculated, it would only be a very small fraction of the dose accumulated via other pathways.

[b] These values for water and fish consumption are taken from EPA's *Exposure Factors Handbook* (EPA 1999). The 9 kilograms per year is the 95th percentile fish consumption for recreational anglers. The 62 kilograms per year is the 95th percentile fish consumption for subsistence fishermen.

[c] The population dose for each alternative is that for the population using the water from Sturgeon Point and several intakes in the East Channel of the Niagara River along with the assumption that each member of this population consumes 0.1 kilograms per year of fish that has been contaminated due to releases from the West Valley Site. The 0.1-kilogram per year is based on a five-year average New York fish yield from Lake Erie (102,000 kilograms) distributed over the population that uses the water.

Finally, as noted previously, there is a receptor on the East bank of Franks Creek (opposite the SDA), one on the North bank of Erdman Brook (opposite the NDA), and one in the vicinity of the Low-Level Waste Treatment Facility and lagoons to model radiation dose from exposure to contaminated ground water and soils uncovered by *erosion* of the stream's banks. This receptor is assumed to live in a house on the opposite side of the eroded bank and so is exposed to direct shine. This receptor does not keep a garden on the eroding bank and does not consume deer. In addition, the receptor is assumed to be affected by the inhalation and inadvertent ingestion pathways of the recreational hiking exposure pathway.

H.2 Long-Term Impacts

The purpose of this section is to present estimates of long-term impacts for each of the alternatives. The organization of this section closely parallels that of Section 4.1.10, but more detail is provided.

H.2.1 Sitewide Removal

The Sitewide Removal Alternative is addressed separately because it would require decontamination of the entire site so it is available for unrestricted use. This means that the radiation dose to any reasonably foreseeable onsite receptor would be less than 25 millirem per year. The precise residual contamination is not known with enough precision to warrant an offsite dose analysis, but it is expected that offsite dose consequences would be substantially below that for the Sitewide Close-In-Place Alternative or the No Action Alternative. Estimates of soil removal volumes are provided in the technical reports and are based on available characterization information and the estimated precision of the removal equipment.

Radioactive Contamination

Under this alternative, WNYNSC would be decontaminated during the Decommissioning Period so that any remaining residual radiological contamination would be below the unrestricted use dose criteria of 10 CFR 20.1402. To demonstrate that decontamination is adequate would require analysis of a number of representative, reasonably conservative scenarios to ensure that none of the range of potential human activities on the site would lead to the accumulation of individual radiation doses exceeding the unrestricted use dose criteria. One possible way of achieving this would be to use the analysis of the scenarios to estimate derived concentration guideline levels (DCGLs) that could be used as decontamination targets in various parts of the site. Examples of how this could be done are provided below. In practice, official DCGLS will be developed through the Decommissioning Plan process.

Two exposure scenarios have been identified for the illustrative determination of DCGLs; a resident farmer scenario and a recreational hiker scenario. Estimates of the radionuclide-specific DCGLs for these two scenarios are presented in **Tables H–18** and **H–19**. See Appendix G, Section G.2.1 for further details.

Table H–18 Examples of Radionuclide Derived Concentration Guideline Levels that will Result in Total Effective Dose Equivalent of 25 Millirem per Year for the Residential Agriculture Scenario: Water-Dependent Pathways

Nuclide	*Derived Concentration Guidelines (picocuries per gram)*	*Nuclide*	*Derived Concentration Guidelines (picocuries per gram)*
Tritium	1.04×10^3	Thorium-229	2.16×10^1
Carbon-14	2.33×10^1	Thorium-230	1.51
Cobalt-60	3.38	Thorium-232	1.06
Nickel-63	1.84×10^3	Protactinium-231	3.64
Selenium-79	4.62×10^1	Uranium-232	5.51
Strontium-90	4.19	Uranium-233	1.46×10^1
Technetium-99	1.44×10^1	Uranium-234	1.52×10^1
Antimony-125	2.43×10^1	Uranium-235	1.49×10^1
Iodine-129	1.67	Uranium-236	1.59×10^1
Cesium-137	1.11×10^1	Uranium-238	1.53×10^1
Promethium-147	6.30×10^4	Neptunium-237	4.73
Samarium-151	1.55×10^5	Plutonium-238	1.70×10^2
Europium-154	7.14	Plutonium-239	1.56×10^2
Lead-210	2.44	Plutonium-240	1.56×10^2
Radium-226	1.20	Plutonium-241	5.53×10^3
Radium-228	1.37	Americium-241	1.68×10^2
Actinium-227	9.66	Curium-243	6.76×10^1
Thorium-228	6.04	Curium-244	3.35×10^2

Table H–19 Examples of Radionuclide Derived Concentration Guidelines that will Result in Total Effective Dose Equivalent of 25 Millirem per Year for the Recreational Scenario

Nuclide	*Derived Concentration Guidelines (picocuries per gram)*	*Nuclide*	*Derived Concentration Guidelines (picocuries per gram)*
Tritium	2.72×10^4	Thorium-229	1.58×10^1
Carbon-14	3.16×10^5	Thorium-230	2.91
Cobalt-60	11.4	Thorium-232	1.21
Nickel-63	1.03×10^6	Protactinium-231	1.07×10^1
Selenium-79	5.13×10^4	Uranium-232	3.09
Strontium-90	9.23×10^2	Uranium-233	1.53×10^3
Technetium-99	1.13×10^5	Uranium-234	2.95×10^3
Antimony-125	1.26×10^1	Uranium-235	3.50×10^1
Iodine-129	8.29×10^2	Uranium-236	3.14×10^3
Cesium-137	8.23	Uranium-238	1.69×10^2
Promethium-147	3.18×10^5	Neptunium-237	2.42×10^1
Samarium-151	1.48×10^6	Plutonium-238	6.33×10^2
Europium-154	11.70	Plutonium-239	5.78×10^2
Lead-210	8.13×10^1	Plutonium-240	5.80×10^1
Radium-226	2.40	Plutonium-241	1.10×10^4
Radium-228	2.78	Americium-241	3.30×10^2
Actinium-227	1.22×10^1	Curium-243	4.43×10^1
Thorium-228	3.15	Curium-244	1.23×10^3

For mixtures of radionuclides a DCGL referenced to a single radionuclide was calculated using the formula:

$$DCGL_j = 1 / \Sigma (f_i / DCGL_i) \qquad \textit{(H-1)}$$

where:

$DCGL_j$ is the mixture DCGL referenced to radionuclide j,
$DCGL_i$ is the DCGL for individual radionuclide i, and
f_i is the ratio of the concentration of individual radionuclide i to that of the reference radionuclide j, and the summation is taken over all radionuclides in the mixture.

The meaning of $DCGL_j$ is that, if a sufficient percentage of the mixture is removed such that the concentration of radionuclide j is less than $DCGL_j$, then the concentration of all other radionuclides will be such that the area containing the mixture has been sufficiently decontaminated to meet unrestricted use dose criteria, assuming an equal percentage removal of all radionuclides.

Hazardous Chemical Contamination

Under this alternative, WNYNSC would be decontaminated during the Decommissioning Period so that residual hazardous material contamination would not result in a situation where the concentration would exceed criteria for clean closure. The criteria could include NYSDEC TAGM-4046, *Determination of Soil Cleanup Objectives and Cleanup Levels* and NYSDEC Division of Water, Technical and Operational Guidance Series 1.1.1, *Ambient Water Quality Standards and Guidance Values and Groundwater Effluent Limitations* or other agency-approved cleanup objectives that are protective of human health and the environment (e.g., risk-based action levels).

H.2.2 Sitewide Close-In-Place and No Action Alternatives

The remainder of this analysis addresses the impacts that would be expected to result from implementing the Sitewide Close-In-Place Alternative and the No Action Alternative, respectively.[4] These two alternatives would have some amount of hazardous and radioactive material remaining onsite. The analysis addresses the impacts to a spectrum of individual and population receptors located outside the current WNYNSC boundary as a result of releases to the local groundwater that then discharges to the onsite streams (Erdman Brook, Franks Creek and Buttermilk Creek). It also addresses the effects of radionuclide releases on individual receptors and the local population, and the effect of both radionuclide and hazardous chemical releases on the two closest offsite individual receptors. The analysis of the Sitewide Close-in-Place and No Action Alternatives is organized as follows:

Section H.2.2.1 presents a summary description of parameters used in the impact analysis. Values of parameters characterizing receptor behavior are those already summarized in Section H.1.3.

Section H.2.2.2 deals with impacts given assumed indefinite continuation of institutional controls. These impacts take credit for institutional controls to prevent access to the waste management areas, to maintain the integrity of structures such as the Main Plant Process Building, together with engineered features such as erosion control structures and engineered caps.

Section H.2.2.3 deals with impacts assuming loss of institutional controls. In this case it is assumed that institutional controls will be lost after 100 years. In particular, it is assumed that there are no more efforts to contain radionuclides and hazardous chemicals within the Main Plant Process Building, the Vitrification Facility, and the Waste Tank Farms. Conservatively, these are assumed to fail as soon as institutional controls fail. This subsection reexamines the analysis for the offsite receptors and also considers failure of institutional controls that would allow intruders to enter the WNYNSC and various waste management areas.

Section H.2.2.3 considers failure of institutional controls leading to unmitigated erosion. The offsite receptors are again reanalyzed. In addition, this section considers onsite receptors on the banks of Franks Creek and Erdman Brook who would be exposed to direct radiation shine from eroded surfaces.[5] A summary of other sources of radiation to which these receptors would be exposed is given in Section H.2.2.2.7.

The analytical results presented here are from deterministic runs that are considered to be conservative,[6] except for those that include unmitigated erosion, in which case an "intermediate" estimate is presented corresponding to the case in which the site becomes partly forested and partly grassland. More details on both the deterministic and sensitivity/uncertainty analyses are presented in Section H.3.

H.2.2.1 Parameters Used in the Impact Analysis

A primary set of information used in impact analysis consists of the conditions of groundwater flow. The sitewide and near-field flow models used to develop this description of groundwater flow conditions are described in Appendix E. In that appendix, results of solute transport simulations with three-dimensional models indicated that plumes originating from given locations on the North Plateau followed nearly direct paths to points of discharge (Figures E–38 and E–39). In addition, one-dimensional simulation of

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[4] *There is no quantitative long-term performance assessment for the preferred alternative, Phased Decisionmaking, because the long-term impact depends on the final condition, which is yet to be defined. There is a qualitative discussion of long-term impacts for the preferred alternative in Section H.2.3.*
[5] *In this appendix, calculations of dose from external irradiation are performed using the Microshield computer model and include both direct shine from eroded surfaces and skyshine. However, the modeling did not consider ground shine from radioactive materials deposited directly onto creek banks.*
[6] *The major assumptions that contribute to the assessment that the estimates of dose are conservative are listed in section 4.3.5.*

concentration of strontium-90 in the North Plateau Groundwater Plume provided a reasonable match with the results of three-dimensional transport simulation and with measured concentrations along the centerline of the plume. On this basis, one-dimensional groundwater flow models were selected for human health impacts analysis. In each case, the width of the flow tube is the width of the source. The value of longitudinal dispersivity is 1/10 of the distance from the source to the nearest point at which a receptor contacts the groundwater for all sources except for the North Plateau Groundwater Plume for which the value of 5 meters determined by comparison to data (see Appendix E) is used.

Values of groundwater flow velocities extracted from the three-dimensional model results for use in one-dimensional models are summarized in **Table H–20**. In addition to this flow information, estimation of concentrations of contaminants in the North Plateau Groundwater Plume at the initiation time (calendar year 2020) of long-term performance assessment is required. The approach taken to the development of this information was to use the inventory estimate for the North Plateau Groundwater Plume presented in Appendix C and the one-dimensional flow model to estimate the concentration of contaminants in the plume in calendar year 2020 given a release in calendar year 1968. The results of this calculation, assumed applicable for both the No Action and Sitewide Close-In-Place Alternatives, are presented in **Table H–21**. Consistent with the relatively rapid movement of groundwater in the thick-bedded unit and the slack-water sequence on the North Plateau, relatively mobile radionuclides such as tritium-3, technetium-99 and iodine-129 would have discharged from the aquifer prior to calendar year 2020.

Table H–20 Groundwater Flow Velocities for Human Health Impact Analysis

Facility	*Geohydrologic Unit*	*Average Linear Velocity (meters per year)*	
		Sitewide Close-In-Place Alternative	*No Action Alternative*
North Plateau			
Main Plant Process Building	Slack-water Sequence	97	115
Vitrification Facility	Slack-water Sequence	97	115
Waste Tank Farm	Thick-bedded Unit	65	75
Low-Level Waste Treatment Facility	Thick-bedded Unit	98	120
South Plateau			
NDA [a]			
Horizontal	Weathered Lavery Till	0.70(P),0.30(H),0.66(W)	0.85(P),0.36(H),0.77(W)
Vertical	Unweathered Lavery Till	0.077(P),0.176(H),0.096(W)	0.074(P),0.176(H),0.096(W)
SDA			
Horizontal	Weathered Lavery Till	0.76	0.79
Vertical	Unweathered Lavery Till	0.071	0.071

NDA = NRC-licensed Disposal Area, SDA = State-licensed Disposal Area.

[a] The parenthetical labels P and H denote the Nuclear Fuel Services process and hulls disposal areas of the NDA while the label W denotes the West Valley Demonstration Project disposal area of the NDA.

Table H–21 Estimated Concentrations in the North Plateau Groundwater Plume for Calendar Year 2020

Distance [a] (meters)	*Concentration (picocuries per liter)*				
	Carbon-14	*Strontium-90*	*Uranium-238*	*Neptunium-237*	*Plutonium-239*
0	0	0.4	0	0	0.01
50	0.1	4,790	0.15	0.02	35.0
100	2.3	106,000	0.39	0.44	90.0
150	6.6	294,000	0.02	1.20	5.0
200	2.6	118,000	0	0.50	0.007
250	0.16	6,910	0	0.03	0
300	0.001	60	0	0	0

[a] Coordinates for the source initially located at distance of 20 meters.

Engineered barriers and natural materials considered in this performance assessment include the ability to divert or control flow. The flow control structures considered in the analysis include the drainage and underlying clay layers of engineered caps, the subsurface slurry walls on the North and South Plateaus, the Controlled Low Strength Material (a form of grout) used to fill the tanks of the Waste Tank Farm, and the grout used to stabilize sediments at lagoons 1, 2, and 3 of the Low-Level Waste Treatment Facility. The values of hydraulic conductivity that control the functional capacities of these barriers are well defined by design at the time of installation but may degrade over time. Because the rate of degradation would be difficult to predict, *degraded values of hydraulic conductivity are assumed to apply over the entire time period of the long-term performance assessment, irrespective of whether institutional controls are maintained or fail.*

Literature review of the performance of drainage layers identified particulate plugging and biofilm growth as the primary modes of degradation (Rowe et al. 2004). However, it is also reported that proper choice of gravel size and with quality assurance for installation, coarse gravel can maintain high hydraulic conductivity in operation (Rowe et al. 2004). Based on these considerations and in order to provide a conservative assessment of performance, a value of hydraulic conductivity of 0.03 centimeters pre second was adopted for drainage layers in the engineered caps. This value is two orders of magnitude less than the design value of the gravel and at the upper end of the range of values reported for sand (Meyer and Gee 1999).

Literature review of performance of clay layers identified dessication as the primary failure mechanism for this type of barrier (Rowe et al. 2004). The study also reported excellent performance when the layers were maintained in the saturated state. On this basis, a degraded valued of hydraulic conductivity of clay layers in the center of engineered caps of 5×10^{-8} centimeters per second was adopted. This value is one order of magnitude higher than the design value.

Also based on these considerations, additional degradation of performance is assumed for slurry walls extending to the ground surface. Although the offset in hydraulic conductivity between the slurry wall and the surrounding natural material is large and would be expected to maintain near saturated conditions in a humid environment such as West Valley, a two-order of magnitude degradation in design value of hydraulic conductivity was assumed for this analysis. The value adopted for hydraulic conductivity of slurry walls was 1×10^{-6} centimeters per second. Values of hydraulic conductivity reported for intact concrete range from 1×10^{-10} to 1×10^{-8} centimeters per second (Clifton and Knab 1989). In order to account for degradation and potential effectiveness of placement, a value of 1×10^{-5} centimeters per second was used for Controlled Low Strength Material and grout in the long-term performance assessment.

The above cited values of hydraulic properties are used in the near-field groundwater flow models to estimate rates of flow through waste materials. The results of these calculations for facilities on the North Plateau are presented in **Tables H–22** and **H–23** for the No Action and Sitewide Close-In-Place Alternatives, respectively. Differences in volumetric flow rates reported in these two tables are related to placement of engineered barriers while differences in waste volume are related to decontamination and closure activities. On the South Plateau, waste is simulated as mixed with soil in holes and trenches and groundwater velocities through the waste are those reported in Table H–20 for the geohydrologic unit in which the waste is located. Flow areas and waste volumes used in simulation of the South Plateau facilities are presented in **Table H–24**. Estimates of radiological and chemical constituent inventories are presented in Appendix C.

Table H–22 Flow Rates Through Waste Disposal Volumes for North Plateau Facilities for the No Action Alternative

Facility	*Flow Area Through Waste (square meters)*	*Disposal Volume (cubic meters)*	*Flow Direction*	*Volumetric Flow Rate Through Waste (cubic meters per year)*
Main Plant Process Building				
General Purpose Cell	3	42	Horizontal	78
Liquid Waste Cell	102	102	Vertical	26
Fuel Receiving and Storage Pool	12	240	Horizontal	310
Rubble Pile	3,200	14,000	Vertical	835
Vitrification Facility	79	340	Vertical	21
Waste Tank Farm				
Tank 8D-1	19	357	Horizontal	66
Tank 8D-2	38	357	Horizontal	181
Tank 8D-3	3	10	Horizontal	16
Tank 8D-4	3	10	Horizontal	16
Low-Level Waste Treatment Facility				
Lagoon 1	35	605	Horizontal	940
Lagoon 2	1.4	84	Horizontal	38
Lagoon 3	1.7	102	Horizontal	46
Lagoon 4	1.1	29	Horizontal	30
Lagoon 5	1.1	29	Horizontal	30

Table H–23 Flow Rates Through Waste Disposal Volumes for North Plateau Facilities for the Sitewide Close-In-Place Alternative

Facility	*Flow Area Through Waste (square meters)*	*Disposal Volume (cubic meters)*	*Flow Direction*	*Volumetric Flow Rate Through Waste (cubic meters per year)*
Main Plant Process Building				
General Purpose Cell	45	40	Vertical	2.3
Liquid Waste Cell	102	245	Vertical	2.2
Fuel Receiving and Storage Pool	260	40	Vertical	13.3
Rubble Pile	12,000	12,000	Vertical	194
Vitrification Facility	79	12	Vertical	1.7
Waste Tank Farm				
Tank 8D-1	357	357	Vertical	10.6
Tank 8D-2	357	357	Vertical	10.6
Tank 8D-3	13	13	Vertical	0.21
Tank 8D-4	13	13	Vertical	0.21
Low-Level Waste Treatment Facility				
Lagoon 1	35	605	Horizontal	0.52
Lagoon 2	4.2	252	Horizontal	2.0
Lagoon 3	5.1	306	Horizontal	1.2
Lagoon 4	3.3	86	Horizontal	48
Lagoon 5	3.3	86	Horizontal	58

Table H–24 Flow Areas and Disposal Area Volumes for Facilities on the South Plateau

Facility	*Disposal/Waste Area Volume (cubic meters)*	*Flow Area (square meters)*	
		Horizontal Flow Path	*Vertical Flow Path*
NDA			
Nuclear Fuel Services Process	5,500	220	2,200
Nuclear Fuel Services Hulls	3,000	40	200
West Valley Demonstration Project	12,800	160	1,600
SDA	120,000	1,200	20,000

NDA = NRC-licensed Disposal Area, SDA = State-licensed Disposal Area.

Values of distribution coefficient characterizing retention in natural and engineered materials are also applied for analysis of transport of solutes. Values of distribution coefficient used for aquifer soils, concrete and Controlled Low Strength Material are presented in **Table H–25**. The approach taken for these selections is to use values for un-degraded material for short-lived constituents expected to decay during the expected life of the engineered material, such as strontium-90 and cesium-137, and degraded values for those elements expected to remain for long periods of time. The expected lifetimes of the engineered grouts are on the order of 500 years (Clifton and Knab 1989, Atkinson and Hearn 1984). While decrease in retention of elements on cement with degradation has been reported (Bradbury and Sarott 1995), high retention of actinide elements is reported for even for degraded cements.

The Controlled Low Strength Material is a grout-based mixture that is expected to include zeolite and apatite minerals as aggregates. Characterization of grouted materials has established that cesium and strontium are retained primary on the aggregates used in the concrete while other elements are retained both on the aggregate and on the calcium silicate hydrogel matrix of the concrete (Stinton et al. 1984). High retention of cesium on zeolite (Lonin and Krasnopyorova 2004) and of strontium and heavier elements on apatite (Krejzler and Narbutt 2003) has been documented.

For high-density concrete as used in contaminated portions of site facilities, retention of strontium and cesium is expected to occur on the sand ballast while retention of actinides is expected to occur on the degraded cement material. On the basis of the above considerations, the values of Table H–20 primarily characteristic of sand (Sheppard and Thibault 1990) are proposed for cement materials. The increased value for neptunium in Controlled Low Strength Material is related to presence of apatite. For aquifer soils, the values are derived from site specific measurements for strontium and uranium (Dames and Moore 1995a, 1995b) and from national survey data for sand (Sheppard and Thibault 1990). These values are applied to both the sandy units of the North Plateau and the silt-clay soils underlying both the North and South Plateaus.

Table H–25 Values of Distribution Coefficient for Long-term Impact Analysis

Element	*Distribution Coefficient (milliliters per gram)*		
	Aquifer	***Concrete***	***Controlled Low Strength Material***
Hydrogen	0	1.0	1.0
Carbon	5	5	5
Strontium	5	15	15
Technetium	0.1	1.0	1.0
Iodine	1	1	1
Cesium	280	280	280
Uranium	10	10	35
Neptunium	5	5	60
Plutonium	550	550	550
Americium	1,900	1,900	1,900

H.2.2.2 Indefinite Continuation of Institutional Controls

This section presents long-term radiological dose and long-term radiological and hazardous chemical risk to offsite receptors and populations. Assuming that institutional controls continue indefinitely is clearly optimistic. The results of the calculations represent a lower bound on potential health impacts. The section is organized by receptor beginning with the nearest offsite receptor and progressing to the farthest and discusses the impacts to these receptors following releases to the local groundwater, discharges to the onsite streams (Erdman Brook, Franks Creek and Buttermilk Creek), and flow into Cattaraugus Creek.

In this case of indefinite continuation of institutional controls, it is assumed that maintenance actions for the Main Plant Process Building, the Vitrification Facility, and the Waste Tank farm would keep engineered systems (e.g., drying systems, and roofs) operating indefinitely. The doses from these units would be minimal as long as the engineered systems function as originally designed and institutional controls prevent releases. These maintenance actions and their associated costs are described in the No Action technical report, which is a primary reference for this EIS.

H.2.2.2.1 Cattaraugus Creek Receptor

This sub-section focuses on the Cattaraugus Creek receptor (just outside the site boundary) and first considers exposures to radionuclides, followed by a discussion of exposures to chemicals. The Cattaraugus Creek receptor is a postulated offsite receptor who is closest to the site boundary and receives the impact of liquid release from all portions of the site. This receptor is conservatively assumed to drink water from Cattaraugus Creek, eat fish and deer, and irrigate his garden, also with water from Cattaraugus Creek.

Radiological Dose and Risk

This section covers total effective dose equivalent (TEDE), dominant doses and pathways, and radiological risk.

Total Effective Dose Equivalent

Figures H–4 and **H–5** present the annual TEDE as a function of time to a Cattaraugus Creek receptor located just outside the WNYNSC boundary. This hypothetical individual is postulated to drink water from Cattaraugus Creek, use the water for irrigation and consume fish raised in the Cattaraugus Creek. Detailed information on the timing and magnitude of peak dose is presented in Tables H–26 and H–27. For each alternative and for both the NDA and SDA, the time series of dose represents the combined effect of horizontal transport through the weathered Lavery till and vertical and horizontal flow through the unweathered Lavery till and Kent Recessional Sequence. The models used to predict the doses and risks presented in Figures H–3 and H–4 and in many of the subsequent tables and figures are described in Appendix G. The analyses were performed consistent with the general approach outlined in Appendix D.

For the Sitewide Close-In-Place Alternative, Figure H–4 shows that the SDA contributes by far the majority of the annual TEDE, with the peak clearly occurring after 30,000-40,000 years. There is an earlier, subsidiary SDA peak occurring at about 1,000 years, and a few minor peaks associated with the. These peaks arrive at different times because different radionuclides leach from the SDA at different rates and percolate through the ground at different rates.

Figure H–5 provides the same information for the No Action Alternative. The figures are virtually identical. This is a consequence of the conservative assumptions about the behavior of engineered barriers as described in Section H.2.2.1, which means that the rates of groundwater flow through areas such as the NDA and SDA are nearly the same for both alternatives for the period for which analysis was performed.

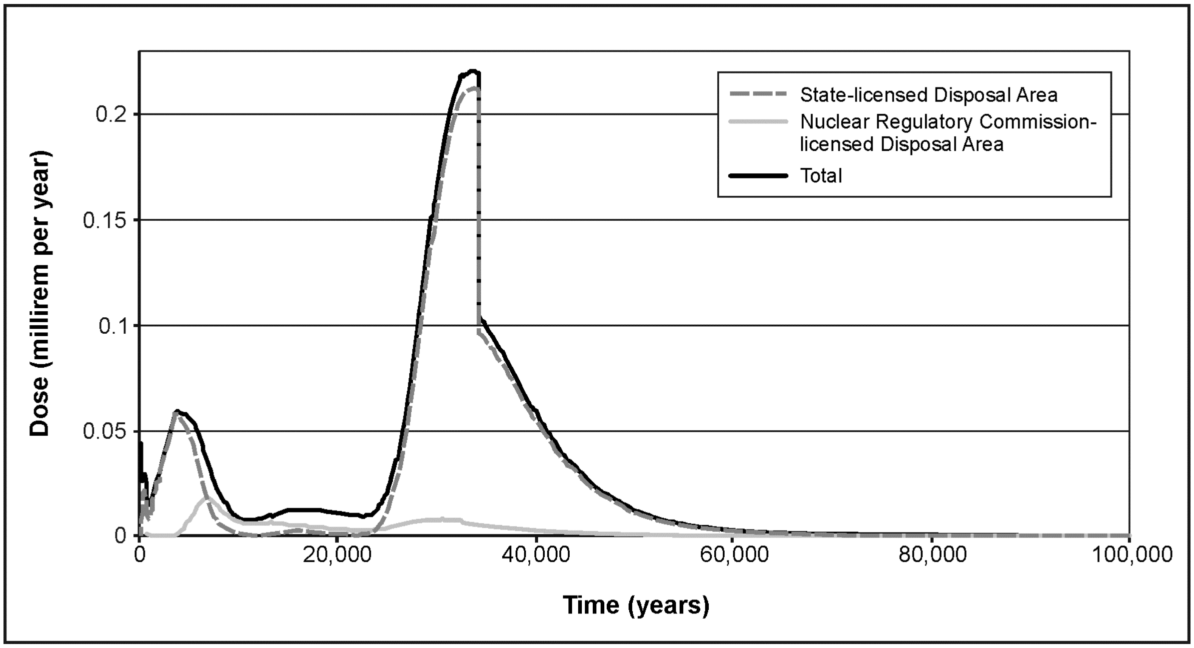

Figure H–4 Annual Total Effective Dose Equivalent for the Cattaraugus Creek Receptor with the Sitewide Close-In-Place Alternative and Indefinite Continuation of Institutional Controls

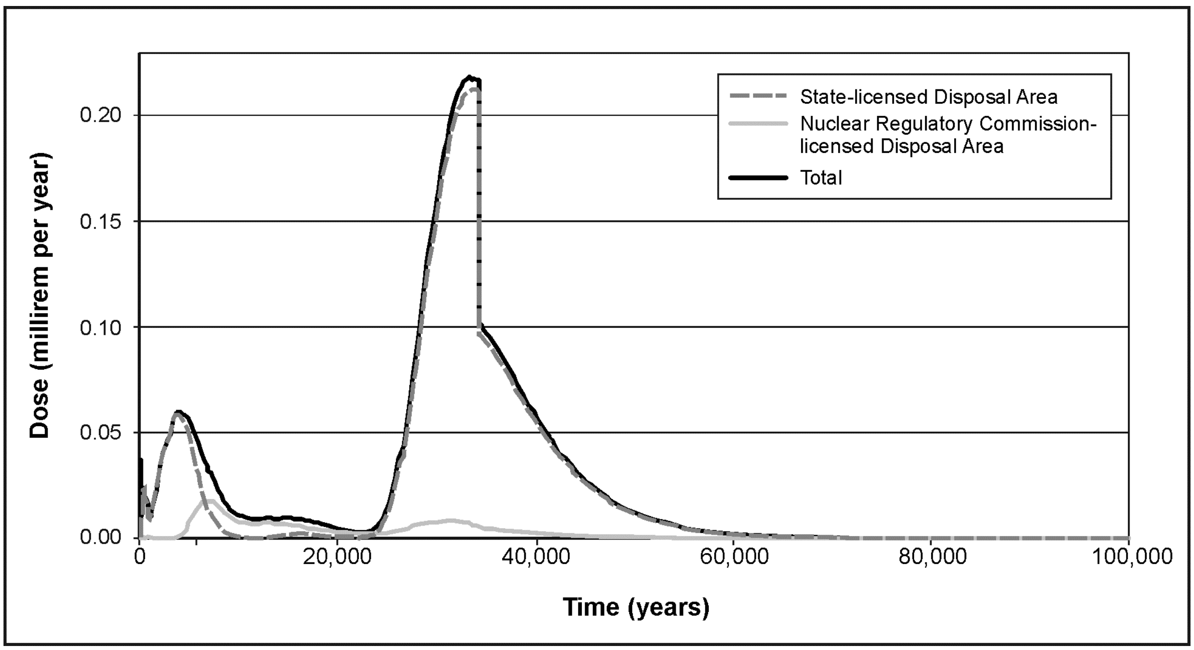

Figure H–5 Annual Total Effective Dose Equivalent for the Cattaraugus Creek Receptor with the No Action Alternative Indefinite Continuation of Institutional Controls

Table H–26 breaks down the predicted peak TEDE arising from radionuclides leaching from each WMA, and the predicted years until peak TEDE for each alternative. This displays the smaller contributors which would not be visible if plotted in Figures H–4 and H–5. In this and other tables the years to peak total dose do not match the years to peak individual WMA dose because, in general, the peak total dose is the sum of doses from individual WMAs that do not coincide with their peaks.

Table H–26 Peak Annual Total Effective Dose Equivalent in Millirem Per Year for the Cattaraugus Creek Receptor (year of peak exposure in parentheses) – Indefinite Continuation of Institutional Controls

Waste Management Areas [a]	*Sitewide Close-In-Place Alternative*	*No Action Alternative*
Main Plant Process Building – WMA 1	0.019 (200)	0 [b]
Vitrification Facility – WMA 1	0.000082 (500)	0 [b]
Low-Level Waste Treatment Facility – WMA 2	0.00015 (100)	0.0092(100)
Waste Tank Farm – WMA 3	0.0029 (200)	0 [b]
NDA – WMA 7	0.018 (6,800) [c]	0.018 (6,800) [c]
SDA – WMA 8	0.21 (33,800) [c]	0.21 (33,800) [c]
North Plateau Groundwater Plume	0.072 (79)	0.11 (68)
Total	0.22 (33,700)	0.22 (33,400)

NDA = NRC-licensed Disposal Area, SDA = State-licensed Disposal Area, WMA = Waste Management Area.

[a] For WMAs 1 through 3, the contributions to dose are presented for the key facilities that contain almost all of the radioactive materials in the WMA. However, no single facility characterizes the burial grounds, so the NDA (WMA 7) and the SDA (WMA 8) are presented as entities in their own right. Other WMAs are not sources of radioactive materials.

[b] It is assumed that proactive maintenance actions would keep engineered systems (caps, drying systems, roofs, etc.) operational indefinitely. The doses from these units would be minimal as long as these engineered systems function as originally designed and institutional control prevents releases from the Main Plant Process Building, the Vitrification Facility, and the Waste Tank Farm.

[c] The reason why the predicted TEDEs and years until peak exposure are the same for the Sitewide Close-In-Place and No Action Alternatives is that it is assumed that the effectiveness of any caps and other mitigating features in the Sitewide Close-In-Place Alternative degrades immediately so that groundwater flow rates and leaching rates are essentially the same for both alternatives.

Detailed Analysis of Total Effective Dose Equivalent

Table H–27 provides further detailed breakdown of Table H–26 organized by components. The SDA is broken into two components, which consist of different pathways whereby radionuclides migrate through the groundwater and eventually end up in Cattaraugus Creek. The first of these is horizontal groundwater flow through the disposal area, and the second is vertical flow through the SDA into a lower-lying horizontally flowing aquifer. Aspects of this are further described in Appendices D, E, and G. The NDA also exhibits the two flowpaths (horizontal and vertical/horizontal) and is further broken down into three components of the waste disposal area, the Nuclear Fuel Services, Inc. (NFS) process, NFS hulls, and WVDP. These are three distinct components of the NDA containing different mixes of hazardous materials and radionuclides. Their geometry also differs (e.g., depth). Radionuclide releases from the hulls provide the largest contribution to the portion of the peak TEDE stemming from the NDA.

Table H–27 Peak Annual Total Effective Dose Equivalent in Millirem Per Year for the Cattaraugus Creek Receptor Broken Down by Waste Management Area Components (year of peak exposure in parentheses) – Indefinite Continuation of Institutional Controls

Waste Management Areas [a]	*Waste Management Area Components*	*Sitewide Close-In-Place Alternative*	*No Action Alternative*
Main Plant Process Building – WMA 1	Rubble Pile	1.4×10^{-3} (800)	b
	General Purpose Cell	6.8×10^{-3} (19,700)	b
	Liquid Waste Cell	1.4×10^{-2} (200)	b
	Fuel Receiving Storage Pad	3.3×10^{-4} (19,800)	b
	Total Main Plant Process Building	1.9×10^{-2} (200)	b
Vitrification Facility – WMA 1		8.2×10^{-5} (500)	b
Low-Level Waste Treatment Facility – WMA 2	Lagoon 1	1.0×10^{-4} (500)	6.9×10^{-3} (100)
	Lagoon 2	5.5×10^{-5} (100)	2.3×10^{-3} (100)
	Lagoon 3	1.5×10^{-7} (500)	5.0×10^{-6} (100)
	Lagoon 4	6.2×10^{-7} (100)	6.8×10^{-7} (100)
	Lagoon 5	2.0×10^{-7} (200)	2.3×10^{-7} (200)
	Total Low-Level Waste Treatment Facility	1.5×10^{-4} (100)	9.2×10^{-3} (100)
Waste Tank Farm – WMA 3	8D-1	1.6×10^{-3} (200)	b
	8D-2	1.4×10^{-3} (200)	b
	8D-3	6.4×10^{-7} (400)	b
	8D-4	2.5×10^{-5} (400)	b
	Total Waste Tank Farm	2.9×10^{-3} (200)	b
NDA – WMA 7 Horizontal	Process	1.7×10^{-3} (18,500)	2.0×10^{-3} (15,400)
	Hulls	2.8×10^{-4} (12,500)	4.2×10^{-4} (10,700)
	West Valley Demonstration Project	1.4×10^{-5} (16,900)	1.5×10^{-5} (14,700)
	Total NDA – Horizontal	2.0×10^{-3} (18,300)	2.3×10^{-3} (14,900)
NDA – WMA 7 Vertical/Horizontal	Process	7.1×10^{-3} (30,900)	7.1×10^{-3} (31,700)
	Hulls	1.8×10^{-2} (6,800)	1.8×10^{-2} (6,800)
	West Valley Demonstration Project	1.2×10^{-4} (21,300)	1.2×10^{-4} (21,300)
	Total NDA – Vertical/ Horizontal	1.8×10^{-2} (6,800)	1.8×10^{-2} (6,800)
Total NDA	Total NDA [c]	1.8×10^{-2} (6,800)	1.8×10^{-2} (6,800)
SDA – WMA 8	Horizontal	4.6×10^{-2} (4,700)	4.6×10^{-2} (4,500)
	Vertical/Horizontal	2.1×10^{-1} (33,700)	2.1×10^{-1} (33,700)
	Total SDA [c]	2.1×10^{-1} (33,800)	2.1×10^{-1} (33,800)
North Plateau Groundwater Plume		7.2×10^{-2} (79)	1.1×10^{-1} (68)
Total Site		2.2×10^{-1} (33,700)	2.2×10^{-1} (33,400)

NDA = NRC-licensed Disposal Area, SDA = State-licensed Disposal Area, WMA = Waste Management Area.

[a] For WMAs 1 through 3, the contributions to dose are presented for the key facilities that contain almost all of the radioactive materials in the WMA. However, no single facility characterizes the burial grounds, so the NDA (WMA 7) and the SDA (WMA 8) are presented as entities in their own right. Other WMAs are not sources of radioactive materials.

[b] It is assumed that proactive maintenance actions would keep engineered systems (caps, drying systems, roofs, etc.) operational indefinitely. The doses from these units would be minimal as long as these engineered systems function as originally designed and institutional control prevents releases from the Main Plant Process Building, the Vitrification Facility, and the Waste Tank Farm.

[c] The reason why the predicted TEDEs and years until peak exposure are the same for the Sitewide Close-In-Place and No Action Alternatives is that it is assumed that the effectiveness of any caps and other mitigating features in the Sitewide Close-In-Place Alternative degrades immediately so that groundwater flow rates and leaching rates are essentially the same for both alternatives.

Controlling Nuclides and Pathways

It is of interest to understand the controlling nuclides and pathways at the years of peak TEDE. **Table H–28** provides this information. As noted above, the SDA provides the largest peak for both alternatives, with both the vertical and horizontal pathways contributing. Table H–28 shows that ingestion of uranium-234 via fish is the dominant contributor for the SDA, and hence is also the dominant contributor for the total dose.

Table H–28 Controlling Nuclides and Pathways for the Cattaraugus Creek Receptor Broken Down by Waste Management Area Components at Year of Peak Annual Total Effective Dose Equivalent – Indefinite Continuation of Institutional Controls

Waste Management Areas [a]	*Waste Management Area Components*	*Controlling Nuclide/Pathway*	
		Sitewide Close-In-Place Alternative	*No Action Alternative*
Main Plant Process Building – WMA 1	Rubble Pile	Iodine-129/Fish	b
	General Purpose Cell	Plutonium-239/Fish	b
	Liquid Waste Cell	Iodine-129/Fish	b
	Fuel Receiving Storage Pad	Plutonium-239/Fish	b
Vitrification Facility – WMA 1		Neptunium-237/Fish	b
Low-Level Waste Treatment Facility – WMA 2	Lagoon 1	Iodine-129/Fish	Strontium-90/DW
	Lagoon 2	Strontium-90/DW	Strontium-90/DW
	Lagoon 3	Uranium-234/DW	Uranium-234/DW
	Lagoon 4	Uranium-234/DW	Uranium-234/DW
	Lagoon 5	Uranium-234/DW	Uranium-234/DW
Waste Tank Farm – WMA 3	8D-1	Technetium-99/RF [c]	b
	8D-2	Technetium-99/RF	b
	8D-3	Technetium-99/RF [c]	b
	8D-4	Iodine-129/Fish	b
NDA – WMA 7 Horizontal	Process	Uranium-233/DW	Uranium-233/DW
	Hulls	Carbon-14/Fish	Carbon-14/Fish
	West Valley Demonstration Project	Uranium-233/DW	Uranium-233/DW
NDA – WMA 7 Vertical/Horizontal	Process	Uranium-233/DW	Uranium-233/DW
	Hulls	Carbon-14/Fish	Carbon-14/Fish
	West Valley Demonstration Project	Uranium-233/DW	Uranium-233/DW
SDA – WMA 8	Horizontal	Uranium-234/Fish	Uranium-234/Fish
	Vertical/Horizontal	Uranium-234/Fish	Uranium-234/Fish
North Plateau Groundwater Plume		Strontium-90/DW	Strontium-90/DW

WMA = Waste Management Area, RF = resident farmer, DW = drinking water, NDA = NRC-licensed Disposal Area, SDA = State-licensed Disposal Area.

[a] For WMAs 1 through 3, the contributions to dose are presented for the key facilities that contain almost all of the radioactive materials in the WMA. However, no single facility characterizes the burial grounds, so the NDA (WMA 7) and the SDA (WMA 8) are presented as entities in their own right. Other WMAs are not sources of radioactive materials.

[b] It is assumed that proactive maintenance actions would keep engineered systems (caps, drying systems, roofs, etc.) operational indefinitely. The doses from these units would be minimal as long as these engineered systems function as originally designed and institutional control prevents releases from the Main Plant Process Building, the Vitrification Facility, and the Waste Tank Farm.

[c] RF means resident farmer and includes a number of pathways such as eating contaminated vegetables, inhalation, etc.

Excess Cancer Risk

A complementary measure is the peak lifetime risk (excess risk of morbidity, or risk of contracting cancer, both fatal and non-fatal) to the Cattaraugus Creek receptor arising from radiological discharges. This risk is calculated assuming a lifetime exposure at the peak predicted dose rate. This introduces an element of conservatism. Note also that the risk is not calculated by the simple method of taking the peak TEDE and multiplying by 6×10^{-4}. The risks are calculated by summing the risks for individual radionuclides using data from FGR-13. **Table H–29** shows how this risk varies from different WMAs and what it is for the entire WNYNSC for each alternative. Since the doses from which the latent cancer morbidity risk is calculated differ little between the alternatives, neither do the risks.

Table H–29 Peak Lifetime Radiological Risk (risk of latent cancer morbidity) for the Cattaraugus Creek Receptor (year of peak risk in parentheses) – Indefinite Continuation of Institutional Controls

Waste Management Areas [a]	*Sitewide Close-In-Place Alternative*	*No Action Alternative*
Main Plant Process Building – WMA 1	3.6×10^{-7} (200)	0 [b]
Vitrification Facility – WMA 1	5.0×10^{-10} (500)	0 [b]
Low-Level Waste Treatment Facility – WMA 2	3.9×10^{-9} (100)	2.0×10^{-7} (100)
Waste Tank Farm – WMA 3	1.3×10^{-7} (200)	0 [b]
NDA – WMA 7	4.7×10^{-7} (6,800) [c]	4.7×10^{-7} (6,800) [c]
SDA – WMA 8	2.7×10^{-6} (33,700) [c]	2.7×10^{-6} (33,700) [c]
North Plateau Groundwater Plume	1.6×10^{-6} (79)	2.4×10^{-6} (68)
Total	2.7×10^{-6} (33,700)	2.7×10^{-6} (33,400)

NDA = NRC-licensed Disposal Area, SDA = State-licensed Disposal Area, WMA = Waste Management Area.

[a] For WMAs 1 through 3, the contributions to dose are presented for the key facilities that contain almost all of the radioactive materials in the WMA. However, no single facility characterizes the burial grounds, so the NDA (WMA 7) and the SDA (WMA 8) are presented as entities in their own right. Other WMAs are not sources of radioactive materials.

[b] It is assumed that proactive maintenance actions would keep engineered systems (caps, drying systems, roofs, etc.) operational indefinitely. The doses from these units would be minimal as long as these engineered systems function as originally designed and institutional control prevents releases from the Main Plant Process Building, the Vitrification Facility, and the Waste Tank Farm.

[c] The reason why the predicted risks and years until peak exposure are the same for the Sitewide Close-In-Place and No Action Alternatives is that it is assumed that the effectiveness of any caps and other mitigating features in the Sitewide Close-In-Place Alternative degrades immediately so that groundwater flow rates and leaching rates are essentially the same for both alternatives.

Hazardous Chemical Risk

Estimates of the risk to the Cattaraugus Creek receptor from hazardous chemicals have also been prepared. Three measures are used: lifetime cancer risk, hazard index and comparison to maximum contaminant levels (MCLs) for drinking water that have been issued under the Clean Water Act. A listing of the hazardous chemicals that were included in the risk analysis is presented in Appendix C.

Lifetime Cancer Risk

Table H–30 shows the peak lifetime cancer risk from chemical exposure broken down by WMA.

Table H–30 shows that, for both alternatives, the SDA is by far the dominant contributor. The NDA peaks are less than 10 percent of those from the SDA. The NDA peak occurs much later because the dominant chemical constituent in the NDA is much less mobile than that in the SDA. Comparing the radiological risk information in Table H–29 with the chemical risk information in Table H–30, it can be seen that the peak lifetime cancer risk to the Cattaraugus Creek receptor is dominated by radionuclides rather than hazardous chemicals. The peak radiological risk is on the order of 100 times greater than the peak chemical risk.

Table H–30 Peak Lifetime Risk from Hazardous Chemicals (risk of latent cancer morbidity) for the Cattaraugus Creek Receptor (year of peak risk in parentheses) – Indefinite Continuation of Institutional Controls

Waste Management Areas [a]	*Sitewide Close-In-Place Alternative*	*No Action Alternative*
Main Plant Process Building – WMA 1	1.3×10^{-10} (6,000)	0 [b]
Vitrification Facility – WMA 1	5.9×10^{-11} (7,400)	0 [b]
Waste Tank Farm – WMA 3	3.1×10^{-10} (9,000)	0 [b]
NDA – WMA 7	1.3×10^{-9} (86,400)	1.3×10^{-9} (88,700)
SDA – WMA 8	2.0×10^{-8} (100)	2.1×10^{-8} (100)
Total	2.0×10^{-8} (100)	2.1×10^{-8} (100)

NDA = NRC-licensed Disposal Area, SDA = State-licensed Disposal Area, WMA = Waste Management Area.

[a] The limited information available on hazardous chemical inventories in the Low-Level Waste Treatment Facility suggest it will not make a noticeable contribution to the overall long-term risk from hazardous chemicals. There is no hazardous chemical inventory available for the Construction and Demolition Debris Landfill in WMA 4.

[b] It is assumed that maintenance actions would keep engineered systems (caps, drying systems, roofs) operational indefinitely. The doses from these units would be minimal as long as these engineered systems function as originally designed and institutional control prevents releases from the Main Plant Process Building, the Vitrification Facility, and the Waste Tank Farm.

[c] The reason why the predicted risks and years until peak exposure are the same for the Sitewide Close-In-Place and No Action Alternatives is that it is assumed that the effectiveness of any caps and other mitigating features in the Sitewide Close-In-Place Alternative degrades immediately so that groundwater flow rates and leaching rates are essentially the same for both alternatives.

This comparison of lifetime cancer risk from radionuclides and chemicals for the Cattaraugus Creek receptor is also shown in **Figures H–6 and H–7**, which confirm that the greatest risk is from the radionuclides except far into the future when both risks are very small. The slight increase in chemical risk far into the future is due to the presence of arsenic, an element whose movement through the groundwater is strongly retarded.

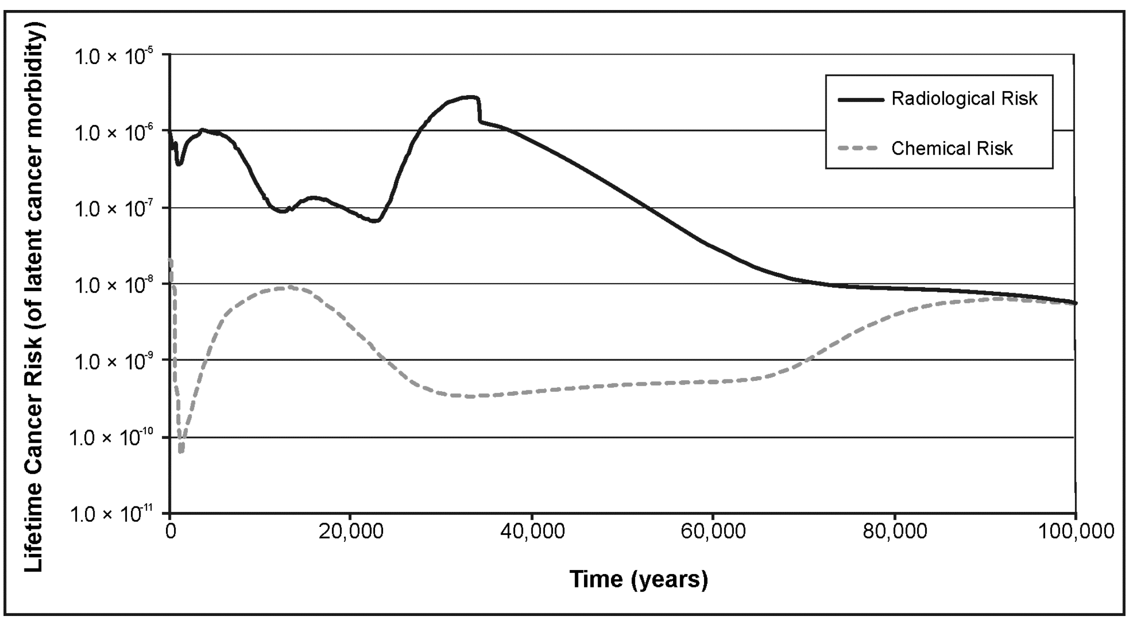

Figure H–6 Lifetime Cancer Risk from Radionuclides and Hazardous Chemicals for the Cattaraugus Creek Receptor with the Sitewide Close-In-Place Alternative and Indefinite Continuation of institutional Controls

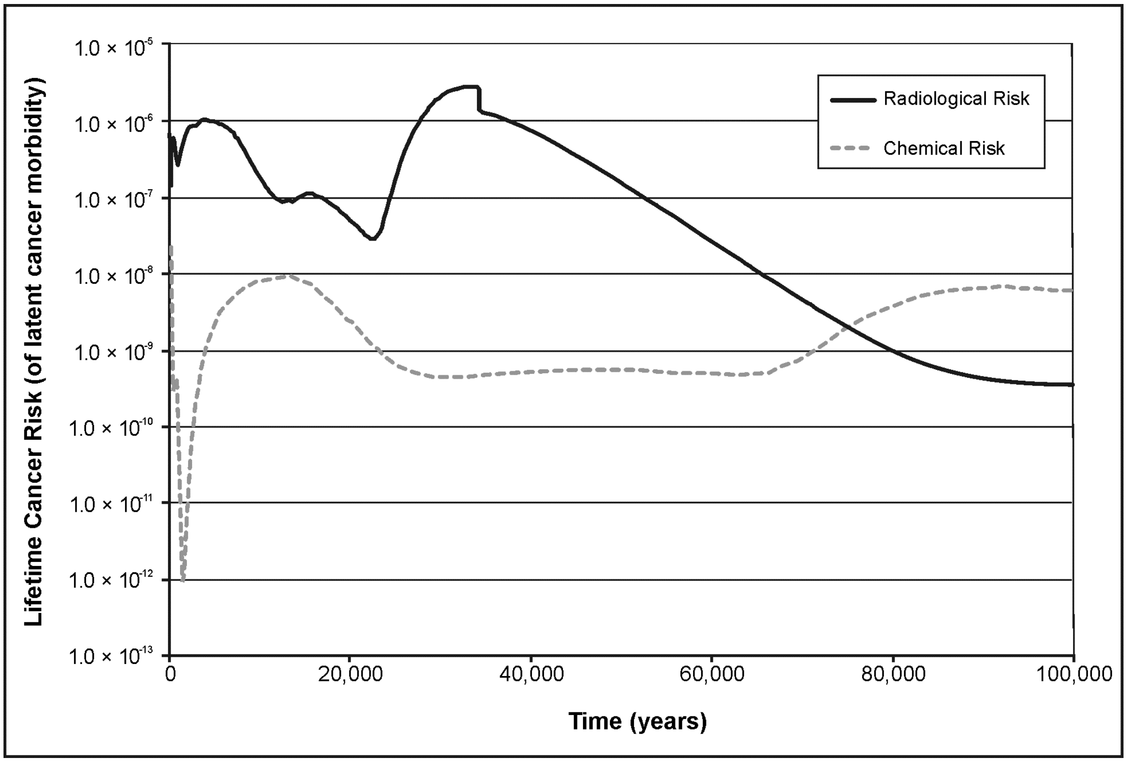

Figure H–7 Lifetime Cancer Risk from Radionuclides and Hazardous Chemicals for the Cattaraugus Creek Receptor with the No Action Alternative and Indefinite Continuation of Institutional Controls

Hazard Index

Another measure of chemical risk that is appropriate for non-carcinogenic chemicals is the hazard index[7] for an individual receptor. If the hazard index is greater than 1, an observable non-carcinogenic health effect may occur. **Table H–31** presents the hazard index peaks for the Cattaraugus Creek receptor in expected conditions. As can be seen, the hazard index peaks are much less than one for both alternatives.

Fraction of Maximum Concentration in Liquid

There are some hazardous chemicals for which there is no carcinogenic slope factor or a reference dose, but they are recognized as hazardous materials and MCLs have been issued under the Clean Water Act. A primary example that is relevant to WNYNSC is lead. When the inventory for a known hazardous material could be estimated, but there was no slope factor or reference dose for the material, an analysis was conducted to determine the maximum concentration of the hazardous material in the years until peak risk and the years until peak hazard index. **Table H–32** shows the results of this analysis. This ratio of peak concentration to MCL would always be less than one and for most elements it would be far less than one (less than 1×10^{-3}).

[7] The Hazard Index is defined as the sum of the hazard quotients for substances that affect the same target organ or organ system. The Hazard Quotient for a specific chemical is the ratio of the exposure to the hazardous chemical (e.g., amount ingested over a given period) to a reference value regarded as corresponding to a threshold of toxicity, or a threshold at which some recognizable health impact would appear. If the hazard quotient for an individual chemical or the hazard quotient for a group of chemicals exceeds unity, the chemical(s) may produce and adverse effect, but normally this will require a hazard index or quotient of several times unity. A hazard index or quotient of less than unity indicates that no adverse effects are expected over the period of exposure.

Table H–31 Peak Chemical Hazard Index for the Cattaraugus Creek Receptor (year of peak hazard index in parentheses) – Indefinite Continuation of Institutional Controls

Waste Management Areas [a]	*Sitewide Close-In-Place Alternative*	*No Action Alternative*
Main Plant Process Building – WMA 1	6.7×10^{-6} (8,100)	0 [b]
Vitrification Facility – WMA 1	2.5×10^{-6} (10,100)	0 [b]
Waste Tank Farm – WMA 3	2.0×10^{-4} (12,400)	0 [b]
NDA – WMA 7	1.4×10^{-5} (30,100) [c]	1.5×10^{-5} (30,900) [c]
SDA – WMA 8	2.8×10^{-3} (4,700) [c]	2.9×10^{-3} (4,500) [c]
Total	2.9×10^{-3} (4,700)	2.9×10^{-3} (4,500)

NDA = NRC-licensed Disposal Area, SDA = State-licensed Disposal Area, WMA = Waste Management Area.

[a] The limited information available on hazardous chemical inventories in the Low-Level Waste Treatment Facility suggest it will not make a noticeable contribution to the overall long-term risk from hazardous chemicals.

[b] It is assumed that maintenance actions would keep engineered systems (caps, drying systems, roofs) operational indefinitely. The health impacts of hazardous chemicals released from these units would be minimal as long as these engineered systems function as originally designed and institutional controls prevents releases from the Main Plant Process Building, the Vitrification Facility, and the Waste Tank Farm.

[c] The reason why the predicted hazard index and years until peak exposure are almost the same for the Sitewide Close-In-Place and No Action Alternatives is that it is assumed that the effectiveness of any caps and other mitigating features in the Sitewide Close-In-Place Alternative degrades immediately so that groundwater flow rates and leaching rates are essentially the same for both alternatives.

Table H–32 Chemicals with Largest Fraction of Maximum Concentration Levels in Cattaraugus Creek at Year of Peak Risk and Year of Peak Hazard Index – Indefinite Continuation of Institutional Controls [a]

Waste Management Areas [b]	*Sitewide Close-In-Place Alternative*	*No Action Alternative*
Year of Peak Risk in Parentheses		
Main Plant Process Building – WMA 1	9.7×10^{-6} (55,100) Pb [d]	– [c]
Vitrification Facility – WMA 1	6.7×10^{-3} (40,500) Pb [d]	– [c]
Waste Tank Farm – WMA 3	2.0×10^{-6} (9,000) Tl [e]	– [c]
NDA – WMA 7	1.3×10^{-6} (86,700) As [f,h]	1.3×10^{-6} (89,200) As [f,,h]
SDA – WMA 8	8.3×10^{-5} (200) Usol [g]	9.0×10^{-5} (100) Usol [g,h]
Year of Peak Hazard Index in Parentheses		
Main Plant Process Building – WMA 1	9.6×10^{-6} (8,100) Pb [d]	– [c]
Vitrification Facility – WMA 1	6.7×10^{-3} (26,000) Pb [d]	– [c]
Waste Tank Farm – WMA 3	2.1×10^{-6} (12,400) Tl [e]	– [c]
NDA – WMA 7	3.4×10^{-5} (30,200) Usol [f,h]	3.4×10^{-5} (31,000) Usol [f,h]
SDA – WMA 8	7.5×10^{-3} (4,700) Usol [g,h]	7.8×10^{-3} (4,500) Usol [g,h]

NDA = NRC-licensed Disposal Area, SDA = State-licensed Disposal Area, WMA = Waste Management Area.

[a] Presented as fraction of the applicable MCL / (years until peak exposure) / chemical.

[b] The limited information available on hazardous chemical inventories in the Low-Level Waste Treatment Facility suggest it will not make a noticeable contribution to the overall long-term risk from hazardous chemicals.

[c] It is assumed that maintenance actions would keep engineered systems (caps, drying systems, roofs) operational indefinitely. The health impacts of hazardous chemicals released from these units would be minimal as long as these engineered systems function as originally designed and institutional controls prevents releases from the Main Plant Process Building, the Vitrification Facility, and the Waste Tank Farm.

[d] Pb = lead, MCL (Action Level) =0.015 milligrams per liter.

[e] Tl= thallium, MCL = 0.002 milligrams per liter.

[f] As = arsenic, MCL = 0.01 milligrams per liter.

[g] Usol = soluble uranium, MCL = 0.03 milligrams per liter.

[h] The reason why the predicted hazard index and years until peak exposure are almost the same for the Sitewide Close-In-Place and No Action Alternatives is that it is assumed that the effectiveness of any caps and other mitigating features in the Sitewide Close-In-Place Alternative degrades immediately so that groundwater flow rates and leaching rates are essentially the same for both alternatives.

H.2.2.2.2 Seneca Nation of Indians Receptor

Another receptor of interest for the WNYNSC is an individual who may engage in subsistence fishing along Cattaraugus Creek. A Seneca Nation of Indian receptor is postulated to use Cattaraugus Creek new Gowanda for drinking water and irrigation of a garden and is also postulated to consume elevated quantities of fish raised in these waters. This sub-section first considers exposure to radionuclides, followed by a discussion of exposure to chemicals. The timing of peaks from individual WMAs presented below are in many respects similar to those for the Cattaraugus Creek receptor although the peak doses themselves are slightly higher.

Radiological Dose and Risk

Total Effective Dose Equivalent

Figures H–8 and H–9 present the annual TEDE as a function of time to a Seneca Nation of Indians receptor located just outside the WNYNSC boundary. This hypothetical individual is postulated to drink water from Cattaraugus Creek, use the water for irrigation and consume fish raised in the Cattaraugus Creek. The principal difference from the Cattaraugus Creek receptor is that the Seneca Nation of Indians receptor consumes more fish. Just as was the case for the Cattaraugus Creek receptor, the SDA is the dominant contributor. However, the peak annual TEDE is about 2.5 times larger than the corresponding peak for the Cattaraugus Creek receptor. As was the case for the Cattaraugus Creek receptor, the figure for the No Action Alternative is almost the same as the figure for the Sitewide Close-In-Place Alternative.

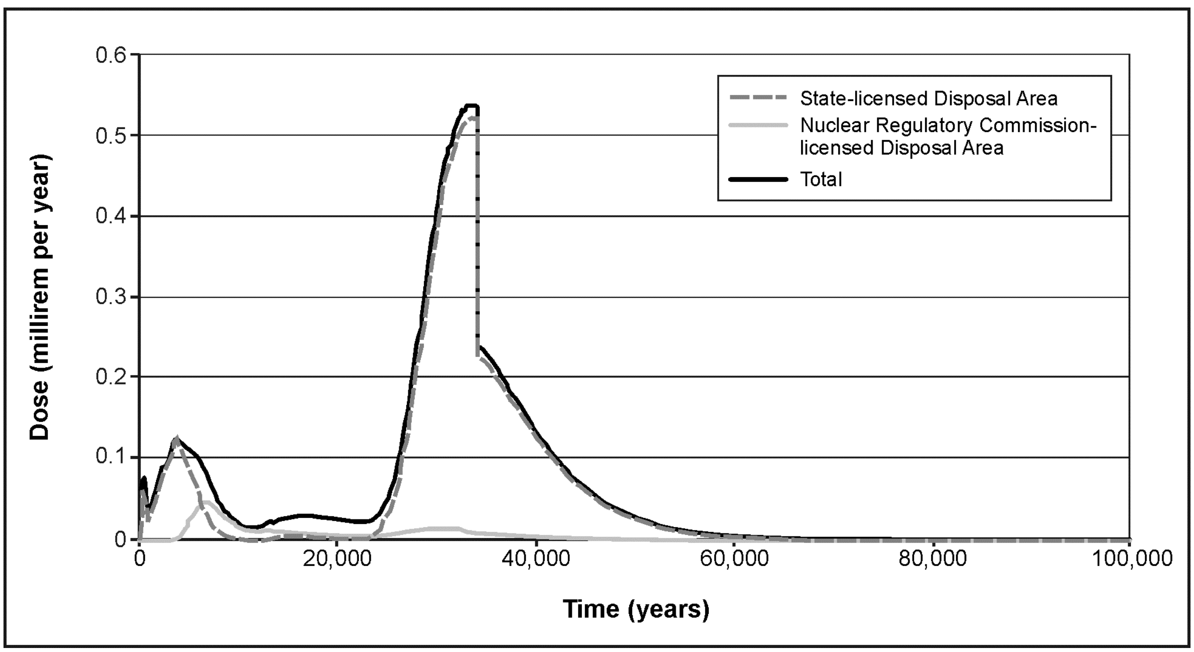

Figure H–8 Annual Total Effective Dose Equivalent for the Seneca Nation of Indians Receptor with the Sitewide Close-In-Place Alternative and Indefinite Continuation of Institutional Controls

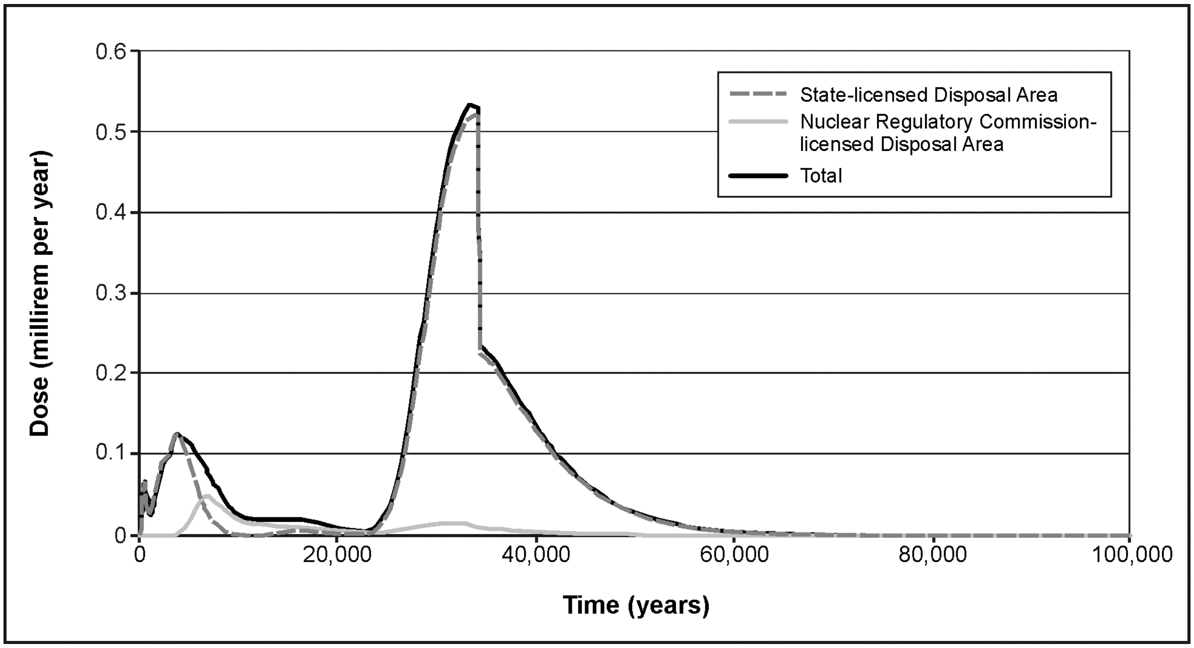

Figure H–9 Annual Total Effective Dose Equivalent for the Seneca Nation of Indians Receptor with the No Action Alternative and Indefinite Continuation of Institutional Controls

The magnitude and the year of the peak contribution are shown in **Table H–33**.

Table H–33 Peak Annual Total Effective Dose Equivalent in Millirem Per Year for the Seneca Nation of Indians Receptor (year of peak exposure in parentheses) – Indefinite Continuation of Institutional Controls

Waste Management Areas [a]	*Sitewide Close-In-Place Alternative*	*No Action Alternative*
Main Plant Process Building – WMA 1	0.052 (200)	0 [b]
Vitrification Facility – WMA 1	0.00020 (500)	0 [b]
Low-Level Waste Treatment Facility – WMA 2	0.00029 (100)	0.015 (100)
Waste Tank Farm – WMA 3	0.0027 (200)	0 [b]
NDA – WMA 7	0.048 [c] (6,800)	0.049 [c] (6,800)
SDA – WMA 8	0.52 [c] (33,800)	0.52 [c] (33,800)
North Plateau Groundwater Plume	0.093 (78)	0.15 (67)
Total	0.54 (33,700)	0.53 (33,400)

NDA = NRC-licensed Disposal Area, SDA = State-licensed Disposal Area, WMA = Waste Management Area.

[a] For WMAs 1 through 3, the contributions to dose are presented for the key facilities that contain almost all of the radioactive materials in the WMA. However, no single facility characterizes the burial grounds, so the NDA (WMA 7) and the SDA (WMA 8) are presented as entities in their own right. Other WMAs are not sources of radioactive materials.

[b] It is assumed that proactive maintenance actions would keep engineered systems (caps, drying systems, roofs, etc.) operational indefinitely. The doses from these units would be minimal as long as these engineered systems function as originally designed and institutional control prevents releases from the Main Plant Process Building, the Vitrification Facility, and the Waste Tank Farm.

[c] The reason why the predicted TEDEs and years until peak exposure are approximately the same for the Sitewide Close-In-Place and No Action Alternatives is that it is assumed that the effectiveness of any caps and other mitigating features in the Sitewide Close-In-Place Alternative degrades immediately so that groundwater flow rates and leaching rates are essentially the same for both alternatives.

The doses for the Seneca Nation of Indians receptor are 2-3 times higher than those for the Cattaraugus Creek receptor. This is due of the large amount of locally raised fish that is postulated to be consumed by this receptor. Table H–33 and Figures H–8 and H–9 show similar patterns to those for the Cattaraugus Creek receptor (Table H–26 and Figures H–4 and H–5) in terms of timing of dose peaks for individual WMAs. **Table H–34** provides further detailed breakdown of Table H–33 organized by components of each WMA. Table H–34 presents information for the Seneca Nation of Indians receptor this is of the type of information presented in Table H–27 for the Cattaraugus Creek receptor.

Controlling Nuclides and Pathways

As for the Cattaraugus Creek receptor, it is of interest to understand the controlling nuclides and pathways at the years until peak TEDE for the Seneca Nation of Indians receptor. **Table H–35** provides this information. As noted above, the SDA provides the largest peak for both alternatives. Table H–35 shows that ingestion of carbon-14, uranium-233, and uranium-234 via fish are important pathways. Table H–28 shows that, for the Cattaraugus Creek receptor, the drinking water pathway is important for releases from some WMA components, and that technetium-99 is a prominent radionuclide. For the Seneca Nation of Indians receptor, fish consumption dominates doses originating from all WMA components, technetium-99 is no longer important, and iodine-129 becomes prominent.

Excess Lifetime Cancer Risk

A complementary measure is the peak lifetime risk to the Seneca Nation of Indians receptor from radiological discharges. **Table H–36** shows how this risk varies from different WMAs and what it is for the entire WNYNSC for each alternative. The lifetime radiological cancer risk to the postulated Seneca Nation of Indians receptor is 2-3 times higher than, the risk to the Cattaraugus Creek receptor as presented in Table H–29. The higher risk is the result of the postulated higher fish consumption. The SDA is the largest contributor to risk.

Hazardous Chemical Risk

Estimates of the risk to the Seneca Nation of Indians receptor from hazardous chemicals in the burial grounds, the Main Plant Process Building and the high-level waste tanks have also been prepared. As for the Cattaraugus Creek receptor, three measures are used: lifetime cancer risk, hazard index and comparison to MCLs for drinking water.

Lifetime Cancer Risk

Table H–37 shows the lifetime excess cancer morbidity risk from exposure to chemicals. As was the case for the Cattaraugus Creek receptor, the SDA dominates the risk. Comparing with Table H–36, the radiological risk is at least two orders of magnitude higher.

The comparison of lifetime cancer risk from radionuclides and chemicals for the Seneca Nation of Indians receptor is also shown in **Figures H–10 and H–11**. These figures for the Seneca Nation of Indians receptor are quite similar to, and can be interpreted in the same way as, Figures H–6 and H–7 for the Cattaraugus Creek receptor.

As was the case for TEDEs (Table H–34), it is possible to break the information in Table H–37 down to more detailed levels. These are available on request, as tables or figures.

Table H–34 Peak Annual Total Effective Dose Equivalent in Millirem Per Year for the Seneca Nation of Indians Receptor Broken Down by Waste Management Area Components (year of peak exposure in parentheses) – Indefinite Continuation of Institutional Controls

Waste Management Areas [a]	*Waste Management Area Components*	*Sitewide Close-In-Place Alternative*	*No Action Alternative*
Main Plant Process Building – WMA 1	Rubble Pile	3.5×10^{-3} (800)	b
	General Purpose Cell	1.7×10^{-2} (19,500)	b
	Liquid Waste Cell	3.8×10^{-2} (200)	b
	Fuel Receiving Storage Pad	8.0×10^{-4} (19,800)	b
	Total Main Plant Process Building	5.2×10^{-2} (200)	b
Vitrification Facility – WMA 1		2.0×10^{-4} (500)	b
Low-Level Waste Treatment Facility – WMA 2	Lagoon 1	1.0×10^{-4} (500)	1.2×10^{-2} (100)
	Lagoon 2	5.5×10^{-5} (100)	2.8×10^{-3} (100)
	Lagoon 3	1.5×10^{-7} (500)	7.1×10^{-6} (100)
	Lagoon 4	6.2×10^{-7} (100)	1.0×10^{-6} (100)
	Lagoon 5	2.9×10^{-7} (200)	3.4×10^{-7} (200)
	Total LLWTF	2.9×10^{-4} (100)	1.5×10^{-2} (100)
Waste Tank Farm – WMA 3	8D-1	1.4×10^{-3} (200)	b
	8D-2	1.3×10^{-3} (200)	b
	8D-3	6.0×10^{-7} (400)	b
	8D-4	5.1×10^{-5} (400)	b
	Total Waste Tank Farm	2.7×10^{-3} (200)	b
NDA – WMA 7 Horizontal	Process	3.2×10^{-3} (18,500)	3.6×10^{-3} (15,400)
	Hulls	7.4×10^{-4} (12,300)	1.1×10^{-3} (10,600)
	WVDP	2.6×10^{-5} (17,100)	2.8×10^{-5} (14,800)
	Total NDA – Horizontal	3.8×10^{-3} (18,000)	4.5×10^{-3} (14,600)
NDA – WMA 7 Vertical/ Horizontal	Process	1.3×10^{-2} (30,900)	1.3×10^{-2} (31,700)
	Hulls	4.8×10^{-2} (6,800)	4.8×10^{-2} (6,800)
	WVDP	2.3×10^{-4} (21,300)	2.3×10^{-4} (21,300)
	Total NDA – Vertical/ Horizontal	4.8×10^{-2} (6,800)	4.8×10^{-2} (6,800)
Total NDA	Total NDA	4.8×10^{-2} (6,800) [c]	4.9×10^{-2} (6,800) [c]
SDA – WMA 8	Horizontal	9.2×10^{-2} (2,900)	9.5×10^{-2} (2,700)
	Vertical/Horizontal	5.2×10^{-1} (33,800)	5.2×10^{-1} (33,800)
	Total SDA	5.2×10^{-1} (33,800) [c]	5.2×10^{-1} (33,800) [c]
North Plateau Groundwater Plume		9.3×10^{-2} (78)	1.5×10^{-1} (67)
Total Site		5.4×10^{-1} (33,700)	5.3×10^{-1} (33,4000)

LLWTF = Low-Level Waste Treatment Facility, NDA = NRC-licensed Disposal Area, SDA = State-licensed Disposal Area, WMA = Waste Management Area, WVDP = West Valley Demonstration Project.

[a] For WMAs 1 through 3, the contributions to dose are presented for the key facilities that contain almost all of the radioactive materials in the WMA. However, no single facility characterizes the burial grounds, so the NDA (WMA 7) and the SDA (WMA 8) are presented as entities in their own right. Other WMAs are not sources of radioactive materials.

[b] It is assumed that proactive maintenance actions would keep engineered systems (caps, drying systems, roofs, etc.) operational indefinitely. The doses from these units would be minimal as long as these engineered systems function as originally designed and institutional control prevents releases from the Main Plant Process Building, the Vitrification Facility, and the Waste Tank Farm.

[c] The reason why the predicted TEDEs and years until peak exposure are the same for the Sitewide Close-In-Place and No Action Alternatives is that it is assumed that the effectiveness of any caps and other mitigating features in the Sitewide Close-In-Place Alternative degrades immediately so that groundwater flow rates and leaching rates are essentially the same for both alternatives.

Table H–35 Controlling Nuclides and Pathways for the Seneca Nation of Indians Receptor Broken Down by Waste Management Area Components at Year of Peak Total Effective Dose Equivalent – Indefinite Continuation of Institutional Controls

Waste Management Areas [a]	*Waste Management Area Components*	*Sitewide Close-In-Place Alternative*	*No Action Alternative*
Main Plant Process Building – WMA 1	Rubble Pile	Iodine-129/Fish	b
	General Purpose Cell	Plutonium-239/Fish	b
	Liquid Waste Cell	Iodine-129/Fish	b
	Fuel Receiving Storage Pad	Plutonium-239/Fish	b
Vitrification Facility – WMA 1		Neptunium-237/Fish	b
Low-Level Waste Treatment Facility – WMA 2	Lagoon 1	Iodine-129/Fish	Iodine-129/Fish
	Lagoon 2	Strontium-90/Fish	Strontium-90/Fish
	Lagoon 3	Uranium-234/Fish	Uranium-234/Fish
	Lagoon 4	Uranium-234/Fish	Uranium-234/Fish
	Lagoon 5	Uranium-234/Fish	Uranium-234/Fish
Waste Tank Farm – WMA 3	8D-1	Iodine-129/Fish	b
	8D-2	Iodine-129/Fish	b
	8D-3	Iodine-129/Fish	b
	8D-4	Iodine-129/Fish	b
NDA – WMA 7 Horizontal	Process	Uranium-233/Fish	Uranium-233/Fish
	Hulls	Carbon-14/Fish	Carbon-14/Fish
	WVDP	Uranium-233/Fish	Uranium-233/Fish
NDA – WMA 7 Vertical/Horizontal	Process	Uranium-233/Fish	Uranium-233/Fish
	Hulls	Carbon-14/Fish	Carbon-14/Fish
	WVDP	Uranium-233/Fish	Uranium-233/Fish
SDA – WMA 8	Horizontal	Carbon-14/Fish	Carbon-14/Fish
	Vertical/Horizontal	Uranium-234/Fish	Uranium-234/Fish
North Plateau Groundwater Plume		Strontium-90/Fish	Strontium-90/Fish

NDA = NRC-licensed Disposal Area, SDA = State-licensed Disposal Area, WMA = Waste Management Area, WVDP = West Valley Demonstration Project.

[a] For WMAs 1 through 3, the contributions to dose are presented for the key facilities that contain almost all of the radioactive materials in the WMA. However, no single facility characterizes the burial grounds, so the NDA (WMA 7) and the SDA (WMA 8) are presented as entities in their own right. Other WMAs are not sources of radioactive materials.

[b] It is assumed that proactive maintenance actions would keep engineered systems (caps, drying systems, roofs, etc.) operational indefinitely. The doses from these units would be minimal as long as these engineered systems function as originally designed and institutional control prevents releases from the Main Plant Process Building, the Vitrification Facility, and the Waste Tank Farm.

Table H–36 Peak Lifetime Radiological Risk (risk of latent cancer morbidity) for the Seneca Nation of Indians Receptor (year of peak risk in parentheses) – Indefinite Continuation of Institutional Controls

Waste Management Areas [a]	*Sitewide Close-In-Place Alternative*	*No Action Alternative*
Main Plant Process Building – WMA 1	1.0×10^{-6} (200)	0 [b]
Vitrification Facility – WMA 1	1.3×10^{-9} (500)	0 [b]
Low-Level Waste Treatment Facility – WMA 2	7.2×10^{-9} (100)	3.4×10^{-7} (100)
Waste Tank Farm – WMA 3	9.6×10^{-8} (200)	0 [b]
NDA – WMA 7	1.3×10^{-6} (6,800)	1.3×10^{-6} (6,800)
SDA – WMA 8	7.5×10^{-6} (33,800)	7.5×10^{-6} (33,800)
North Plateau Groundwater Plume	2.1×10^{-6} (78)	3.4×10^{-6} (67)
Total	7.6×10^{-6} (33,700)	7.6×10^{-6} (33,400)

NDA = NRC-licensed Disposal Area, SDA = State-licensed Disposal Area, WMA = Waste Management Area.

[a] For WMAs 1 through 3, the contributions to dose are presented for the key facilities that contain almost all of the radioactive materials in the WMA. However, no single facility characterizes the burial grounds, so the NDA (WMA 7) and the SDA (WMA 8) are presented as entities in their own right. Other WMAs are not sources of radioactive materials.

[b] It is assumed that proactive maintenance actions would keep engineered systems (caps, drying systems, roofs, etc.) operational indefinitely. The doses from these units would be minimal as long as these engineered systems function as originally designed and institutional control prevents releases from the Main Plant Process Building, the Vitrification Facility, and the Waste Tank Farm.

Table H–37 Peak Lifetime Risk from Hazardous Chemicals (risk of latent cancer morbidity) for the Seneca Nation of Indians Receptor (year of peak risk in parentheses) – Indefinite Continuation of Institutional Controls

Waste Management Areas [a]	*Sitewide Close-In-Place Alternative*	*No Action Alternative*
Main Plant Process Building – WMA 1	2.6×10^{-10} (5,800)	0 [b]
Vitrification Facility – WMA 1	1.2×10^{-10} (5,800)	0 [b]
Waste Tank Farm – WMA 3	6.3×10^{-10} (8,900)	0 [b]
NDA – WMA 7	3.4×10^{-9} (85,800) [c]	3.2×10^{-9} (88,800) [c]
SDA – WMA 8	2.1×10^{-8} (13,400) [c]	2.2×10^{-8} (12,900) [c]
Total	2.1×10^{-8} (13,400)	2.2×10^{-8} (12,900)

NDA = NRC-licensed Disposal Area, SDA = State-licensed Disposal Area, WMA = Waste Management Area.

[a] The limited information available on hazardous chemical inventories in the Low-Level Waste Treatment Facility suggest it will not make a noticeable contribution to the overall long-term risk from hazardous chemicals.

[b] It is assumed that maintenance actions would keep engineered systems (caps, drying systems, roofs) operational indefinitely. The doses from these units would be minimal as long as these engineered systems function as originally designed and institutional control prevents releases from the Main Plant Process Building, the Vitrification Facility, and the Waste Tank Farm.

[c] The reason why the predicted risks and years until peak exposure are the same for the Sitewide Close-In-Place and No Action Alternatives is that it is assumed that the effectiveness of any caps and other mitigating features in the Sitewide Close-In-Place Alternative degrades immediately so that groundwater flow rates and leaching rates are essentially the same for both alternatives.

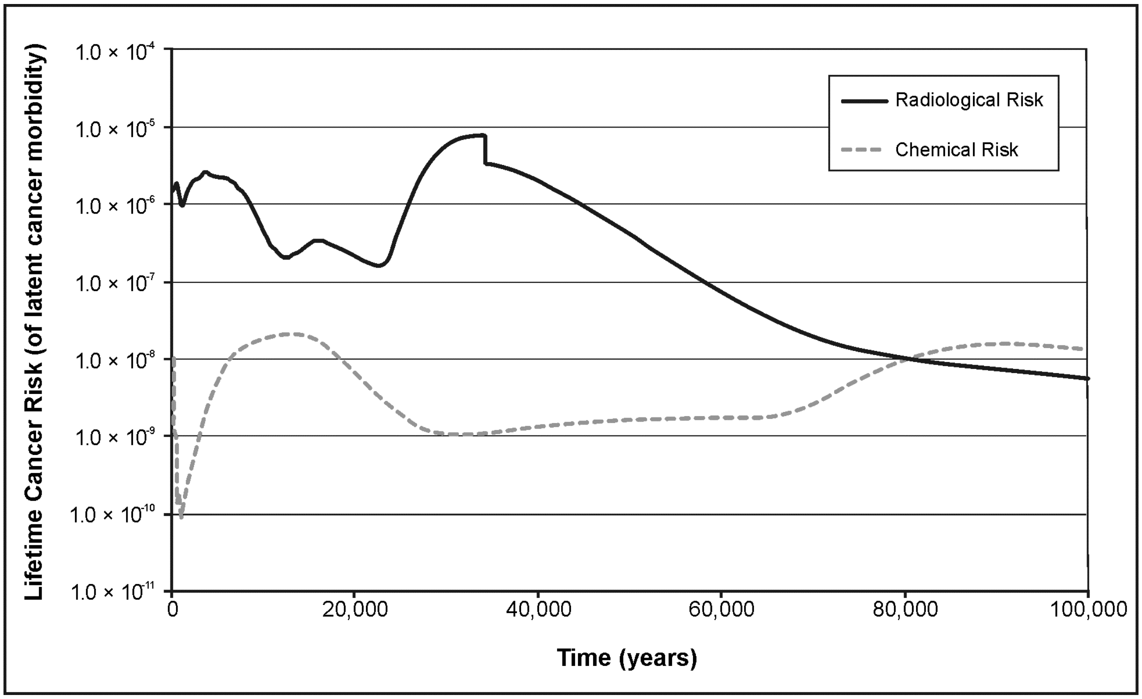

Figure H–10 Lifetime Cancer Risk from Radionuclides and Hazardous Chemicals for the Seneca Nation of Indians Receptor with the Sitewide Closure-In-Place Alternative and Indefinite Continuation of Institutional Controls

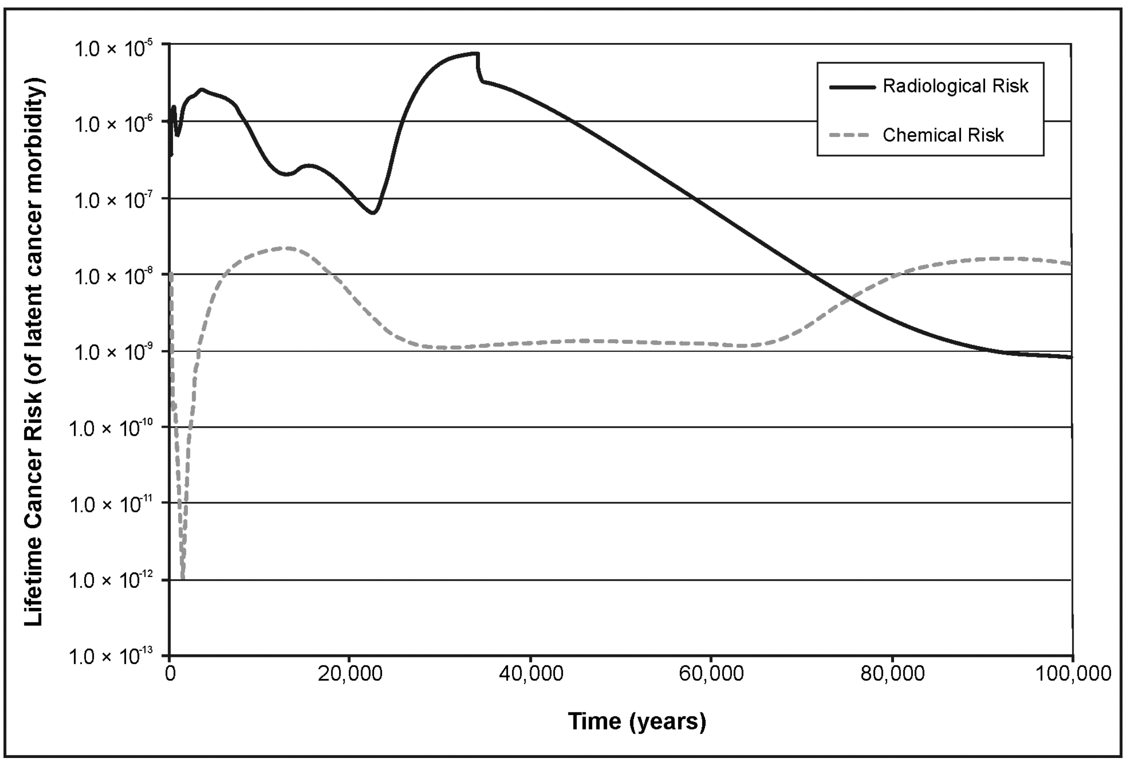

Figure H–11 Lifetime Cancer Risk from Radionuclides and Hazardous Chemicals for the Seneca Nation of Indians Receptor with the No Action Alternative and Indefinite Continuation of Institutional Controls

Hazard Index

Another measure of chemical risk that is appropriate for non-carcinogenic chemicals is the hazard index for an individual receptor. If the hazard index is greater than 1, an observable non-carcinogenic health effect may occur. **Table H–38** presents the hazard index peaks for the Seneca Nation of Indians receptor for indefinite continuation of institutional controls.

The peak annual hazard index for the postulated Seneca Nation of Indians receptor is similar to, and sometimes slightly higher than, the peak annual hazard index for the Cattaraugus Creek receptor. The peak index in no case exceeds 1 percent. This confirms that the risk from non-carcinogenic hazardous chemicals is small.

Table H–38 Peak Chemical Hazard Index for the Seneca Nation of Indians Receptor (year of peak hazard index in parentheses) – Indefinite Continuation of Institutional Controls

Waste Management Areas [a]	*Sitewide Close-In-Place Alternative*	*No Action Alternative*
Main Plant Process Building – WMA 1	1.6×10^{-5} (7,200)	0 [b]
Vitrification Facility – WMA 1	7.0×10^{-6} (17,100)	0 [b]
Waste Tank Farm – WMA 3	6.2×10^{-4} (12,400)	0 [b]
NDA – WMA 7	1.8×10^{-5} (85,900) [c]	1.7×10^{-5} (88,600) [c]
SDA – WMA 8	2.1×10^{-3} (4,700) [c]	2.2×10^{-3} (4,500) [c]
Total	2.4×10^{-3} (4,800)	2.2×10^{-3} (4,500)

NDA = NRC-licensed Disposal Area, SDA = State-licensed Disposal Area, WMA = Waste Management Area.

[a] The limited information available on hazardous chemical inventories in the Low-Level Waste Treatment Facility suggest it will not make a noticeable contribution to the overall long-term risk from hazardous chemicals.

[b] It is assumed that maintenance actions would keep engineered systems (caps, drying systems, roofs) operational indefinitely. The health impacts of hazardous chemicals released from these units would be minimal as long as these engineered systems function as originally designed and institutional controls prevents releases from the Main Plant Process Building, the Vitrification Facility, and the Waste Tank Farm.

[c] The reason why the predicted hazard index and years until peak exposure are almost the same for the Sitewide Close-In-Place and No Action Alternatives is that it is assumed that the effectiveness of any caps and other mitigating features in the Sitewide Close-In-Place Alternative degrades immediately so that groundwater flow rates and leaching rates are essentially the same for both alternatives.

Fraction of Maximum Concentration in Liquid

The MCL is inversely proportional to the flow rate, which, at the Seneca Nation of Indians receptor, is twice that at the Cattaraugus Creek receptor. It follows that fractions of MCL for the Seneca Nation of Indians receptor are half those shown in Table H–34 for the Cattaraugus Creek receptor.

H.2.2.2.3 Lake Erie/Niagara Water River Users

This section discusses population dose, and individual exposures to radioactive materials and chemicals.

Population Dose

In addition to the Cattaraugus Creek and Seneca Nation of Indians individuals, peak annual and time-integrated population dose estimates have been prepared. These are summarized in **Tables H–39** and **H–40**, respectively. Lake Erie water users consume water taken from Sturgeon Point and several structures in the eastern channel of the Niagara River. They are assumed to drink water from Lake Erie or the Niagara River, to eat fish from Lake Erie, and (conservatively) to all be resident farmers.

Table H–39 Peak Annual Total Effective Population Dose Equivalent in person-rem per year for the Lake Erie Water Users (year of peak dose in parentheses) – Indefinite Continuation of Institutional Controls

Waste Management Areas [a]	*Sitewide Close-In-Place Alternative*	*No Action Alternative*
Main Plant Process Building – WMA 1	1.2 (200)	0 [b]
Vitrification Facility – WMA 1	0.0065 (500)	0 [b]
Low-Level Waste Treatment Facility – WMA 2	0.0205(100)	1.5 (100)
Waste Tank Farm – WMA 3	0.66 (200)	0 [b]
NDA – WMA 7	1.1 (30,600) [c]	1.0 (31,500) [c]
SDA – WMA 8	16.9 (33,700) [c]	16.9 (33,700) [c]
North Plateau Groundwater Plume	13.7 (80)	21.5 (67)
Total	17.9 (33,600)	17.9 (33,400)

NDA = NRC-licensed Disposal Area, SDA = State-licensed Disposal Area, WMA = Waste Management Area.

[a] For WMAs 1 through 3, the contributions to dose are presented for the key facilities that contain almost all of the radioactive materials in the WMA. However, no single facility characterizes the burial grounds, so the NDA (WMA 7) and the SDA (WMA 8) are presented as entities in their own right. Other WMAs are not sources of radioactive materials.

[b] It is assumed that proactive maintenance actions would keep engineered systems (caps, drying systems, roofs, etc.) operational indefinitely. The doses from these units would be minimal as long as these engineered systems function as originally designed and institutional control prevents releases from the Main Plant Process Building, the Vitrification Facility, and the Waste Tank Farm.

[c] The reason why the predicted population doses and years until peak exposure are approximately the same for the Sitewide Close-In-Place and No Action Alternatives is that it is assumed that the effectiveness of any caps and other mitigating features in the Sitewide Close-In-Place Alternative degrades immediately so that groundwater flow rates and leaching rates are essentially the same for both alternatives.

Most of the population dose shown in Table H–39 would be received by the users of water from Sturgeon Point and intake which would see higher radionuclide concentrations than the intake structures on the Niagara River. No credit is taken in dilution in the flow between the month of Cattaraugus Creek and the Sturgeon Point intake structure. Complete mixing in the flow of the Niagara River is assumed for water intake points in the Niagara River. The estimated annual background radiation dose for the Sturgeon Point group (565,000 people) would be approximately 200,000 person-rem. The peak annual dose of 18 person-rem for either alternative would be less than a 0.01 percent increase over the estimated annual background radiation dose received by this group.

Table 4–40 presents the time-integrated population dose over periods of 1,000 and 10,000 years. For both alternatives, the total population dose accumulated over 10,000 years (approximately 35,000 person-rem) would be less than the background dose accumulated by Sturgeon Point and Niagara River users in one year (200,000 person rem).

Individual Exposure to Radioactive Material

Tables H–41 and **H–42** contain the predicted peak individual TEDEs from radioactive exposure for Sturgeon Point and Niagara Falls respectively.

The total peak annual TEDEs in Table H–41 (Sturgeon Point) are all about a factor of 17 lower than those for the Seneca Nation of Indians receptor, and a factor of 7 lower than those for the Cattaraugus Creek receptor. The total peak annual TEDEs in Table H–42 (Niagara River) are still lower by more than a further factor of 100. Because the predicted values in Tables H–41 and H–42 are so low, it has been decided not to provide further information in the form of plots or detailed tables. This has already been done for the Cattaraugus Creek and Seneca Nation of Indians receptors: to do the same thing for the Sturgeon Point and Niagara River receptors would provide no new information. Similarly, predicted lifetime risks are comparably lower and are not further discussed here.

Table H–40 Time-Integrated Total Effective Population Dose Equivalent for Lake Erie Water Users (person-rem over 1,000 and 10,000 years) – Indefinite Continuation of Institutional Controls

Waste Management Areas [a]	*Sitewide Close-In-Place Alternative*	*No Action Alternative*
Integration Over 1,000 Years		
Main Plant Process Building – WMA 1	510	0 [b]
Vitrification Facility – WMA 1	4	0 [b]
Low-Level Waste Treatment Facility – WMA 2	9	240
Waste Tank Farm – WMA 3	140	0 [b]
NDA – WMA 7	140 [c]	140 [c]
SDA – WMA 8	600 [c]	620 [c]
North Plateau Groundwater Plume	730	1,000
Total	2,100	2,000
Integration Over 10,000 Years		
Main Plant Process Building – WMA 1	1,000	0 [b]
Vitrification Facility – WMA 1	5	0 [b]
Low-Level Waste Treatment Facility – WMA 2	37	860
Waste Tank Farm – WMA 3	270	0 [b]
NDA – WMA 7	4,100 [c]	4,400 [c]
SDA – WMA 8	29,000 [c]	29,000 [c]
North Plateau Groundwater Plume	750	1,020
Total	35,000	35,000

NDA = NRC-licensed Disposal Area, SDA = State-licensed Disposal Area, WMA = Waste Management Area.

[a] For WMAs 1 through 3, the contributions to dose are presented for the key facilities that contain almost all of the radioactive materials in the WMA. However, no single facility characterizes the burial grounds, so the NDA (WMA 7) and the SDA (WMA 8) are presented as entities in their own right. Other WMAs are not sources of radioactive materials.

[b] It is assumed that proactive maintenance actions would keep engineered systems (caps, drying systems, roofs, etc.) operational indefinitely. The doses from these units would be minimal as long as these engineered systems function as originally designed and institutional control prevents releases from the Main Plant Process Building, the Vitrification Facility, and the Waste Tank Farm.

[c] The reason why the predicted population doses are approximately the same for the Sitewide Close-In-Place and No Action Alternatives is that it is assumed that the effectiveness of any caps and other mitigating features in the Sitewide Close-In-Place Alternative degrades immediately so that groundwater flow rates and leaching rates are essentially the same for both alternatives.

Hazardous Chemical Risk

For the Niagara River and Sturgeon Point users, the peak hazard index, the peak lifetime risk, and the ratio of concentration in water to the MCLs are all smaller than for Cattaraugus Creek or the Seneca Nation of Indians receptor and are not discussed further here.

Conclusions Given Continuation of Institutional Controls

For alternatives where waste would remain onsite, the overall assessment is that the dose and risk is small for both alternatives. The risk is dominated by the radiological hazards. The peak annual dose to offsite receptors is less than 25 millirem per year when considering all WMAs, regardless of the alternative.[8] The radiological hazard for both alternatives is dominated by the burial grounds with the SDA presenting the largest hazard over the longest time period.

[8] *The statement that the doses are less than 25 millirem is not intended to support any regulatory conclusions. Regulatory analysis is presented in Appendix L.*

Table H–41 Peak Annual Total Effective Dose Equivalent in Millirem Per Year for the Sturgeon Point Receptor (year of peak dose in parentheses) – Indefinite Continuation of Institutional Controls

Waste Management Areas [a]	*Sitewide Close-In-Place Alternative*	*No Action Alternative*
Main Plant Process Building – WMA 1	0.0021 (200)	0 [b]
Vitrification Facility – WMA 1	0.000011 (500)	0 [b]
Low-Level Waste Treatment Facility – WMA 2	0.000036 (100)	0.0026 (100)
Waste Tank Farm – WMA 3	0.0012 (200)	0 [b]
NDA – WMA 7	0.0019 (30,600) [c]	0.0018 (31,500) [c]
SDA – WMA 8	0.030 (33,700) [c]	0.030 (33,700) [c]
North Plateau Groundwater Plume	0.024 (80) [d]	0.038 (67)
Total	0.032 (33,600)	0.032 (33,400)

NDA = NRC-licensed Disposal Area, SDA = State-licensed Disposal Area, WMA = Waste Management Area.

[a] For WMAs 1 through 3, the contributions to dose are presented for the key facilities that contain almost all of the radioactive materials in the WMA. However, no single facility characterizes the burial grounds, so the NDA (WMA 7) and the SDA (WMA 8) are presented as entities in their own right. Other WMAs are not sources of radioactive materials.

[b] It is assumed that proactive maintenance actions would keep engineered systems (caps, drying systems, roofs, etc.) operational indefinitely. The doses from these units would be minimal as long as these engineered systems function as originally designed and institutional control prevents releases from the Main Plant Process Building, the Vitrification Facility, and the Waste Tank Farm.

[c] The reason why the predicted TEDEs and years until peak exposure are approximately the same for the Sitewide Close-In-Place and No Action Alternatives is that it is assumed that the effectiveness of any caps and other mitigating features in the Sitewide Close-In-Place Alternative degrades immediately so that groundwater flow rates and leaching rates are essentially the same for both alternatives.

Table H–42 Peak Annual Total Effective Dose Equivalent in Millirem Per Year for the Niagara River Receptor (year of peak dose in parentheses) – Indefinite Continuation of Institutional Controls

Waste Management Areas [a]	*Sitewide Close-In-Place Alternative*	*No Action Alternative*
Main Plant Process Building – WMA 1	7.5×10^{-6} (200)	0 [b]
Vitrification Facility – WMA 1	4.1×10^{-8} (500)	0 [b]
Low-Level Waste Treatment Facility – WMA 2	1.3×10^{-7} (100)	9.5×10^{-6} (100)
Waste Tank Farm – WMA 3	4.2×10^{-6} (200)	0 [b]
NDA – WMA 7	7.0×10^{-6} (30,600) [c]	6.6×10^{-6} (31,400) [c]
SDA – WMA 8	1.1×10^{-4} (33,700) [c]	1.1×10^{-4} (33,700) [c]
North Plateau Groundwater Plume	8.66×10^{-5} (80)	1.4×10^{-4} (67)
Total	1.1×10^{-4} (33,400)	1.1×10^{-4} (100)

NDA = NRC-licensed Disposal Area, SDA = State-licensed Disposal Area, WMA = Waste Management Area.

[a] For WMAs 1 through 3, the contributions to dose are presented for the key facilities that contain almost all of the radioactive materials in the WMA. However, no single facility characterizes the burial grounds, so the NDA (WMA 7) and the SDA (WMA 8) are presented as entities in their own right. Other WMAs are not sources of radioactive materials.

[b] It is assumed that proactive maintenance actions would keep engineered systems (caps, drying systems, roofs, etc.) operational indefinitely. The doses from these units would be minimal as long as these engineered systems function as originally designed and institutional control prevents releases from the Main Plant Process Building, the Vitrification Facility, and the Waste Tank Farm.

[c] The reason why the predicted TEDEs and years until peak exposure are approximately the same for the Sitewide Close-In-Place and No Action Alternatives is that it is assumed that the effectiveness of any caps and other mitigating features in the Sitewide Close-In-Place Alternative degrades immediately so that groundwater flow rates and leaching rates are essentially the same for both alternatives.

H.2.2.3 Conditions Assuming Loss of Institutional Control

The loss of institutional controls is assumed to take place after 100 years. In the case of the No Action Alternative, loss of institutional controls means that all maintenance activities cease and, in particular, no effort is made to keep radionuclides confined within the Main Plant Process Building, the Vitrification Facility, and the Waste Tank Farm. Conservatively, failure of containment of these facilities is assumed to take place immediately upon loss of institutional controls. For the Sitewide Close-In-Place Alternative, however, it is expected that cessation of maintenance and other activities has little effect on the rate of release of radionuclides from areas that dominate dose in this case, such as the SDA and NDA. Finally, for both alternatives, loss of institutional controls means that intruders can enter the site.

The scenarios considered below are: (1) loss of institutional control leading to intruders on Buttermilk Creek; (2) loss of institutional controls leading to intruders on or adjacent to the north and south plateaus; (3) effect of loss of institutional controls on offsite receptors; and (4) loss of institutional control leading to an unmitigated erosion scenario.[9] All of these analyses focus on the impacts of radionuclides being released and coming in contact with human receptors. For radiological health impacts, the discussion is confined to dose impacts only (except for offsite receptors), because there are dose standards for situations following loss of institutional control, but not risk standards.

H.2.2.3.1 Loss of Institutional Controls Leading to Buttermilk Creek Intruder/Resident Farmer

Table H–43 presents the peak annual TEDE for the Buttermilk Creek resident farmer for each alternative, assuming failure of the active controls that would detect and mitigate releases from the process building, the high-level waste tank and the north plateau plume. See Figure H–2 for the location of this receptor.

Table H–43 Peak Annual Total Effective Dose Equivalent in Millirem Per Year for the Buttermilk Creek Resident Farmer (year of peak dose in parentheses) – Loss of Institutional Controls After 100 Years

Waste Management Areas [a]	*Sitewide Close-In-Place Alternative*	*No Action Alternative*
Main Plant Process Building – WMA 1	0.15 (200)	9.9 (100)
Vitrification Facility – WMA 1	0.00062 (500)	1.7 (100)
Low-Level Waste Treatment Facility – WMA 2	0.00079 (100)	0.07 (100)
Waste Tank Farm – WMA 3	0.022 (200)	68 (100)
NDA – WMA 7	0.13 (6,800) [b]	0.14 (6,800) [b]
SDA – WMA 8	1.6 (33,800) [b]	1.6 (33,800) [b]
North Plateau Groundwater Plume	0.54 (79) [c]	0.86 (68) [c]
Total	1.7 (33,700)	80 (100)

NDA = NRC-licensed Disposal Area, SDA = State-licensed Disposal Area, WMA = Waste Management Area.

[a] For WMAs 1 through 3, the contributions to dose are presented for the key facilities that contain almost all of the radioactive materials in the WMA. However, no single facility characterizes the burial grounds, so the NDA (WMA 7) and the SDA (WMA 8) are presented as entities in their own right. Other WMAs are not sources of radioactive materials.

[b] The reason why the predicted TEDEs and years until peak exposure are approximately the same for the Sitewide Close-In-Place and No Action Alternatives is that it is assumed that the effectiveness of any caps and other mitigating features in the Sitewide Close-In-Place Alternative degrades immediately so that groundwater flow rates and leaching rates are essentially the same for both alternatives.

[c] The predicted peak TEDE from the North Plateau Groundwater Plume is slightly less for the No Action Alternative than for the Sitewide Close-In-Place Alternative because mitigating features in the latter case (e.g., hydraulic barriers) slightly reduce the rate of groundwater flow to Cattaraugus Creek, thus resulting in slightly greater predicted concentration of radionuclides.

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[9] *Cases 1-3 consider loss of institutional controls without erosion. Case 4 considers the case with erosion, see Section H.2.2.4. Section H.2.2.4 also contains a qualitative discussion of the combination of doses received as a result of both erosion and releases into groundwater.*

All of the predicted doses for the Sitewide Close-In-Place Alternative would be less than 25 millirem per year. The No Action Alternative would result in the highest peak annual dose to this receptor (80 millirem), dominated by the Waste Tank Farm (68 millirem). If the loss of institutional controls were to occur earlier (i.e., prior to year 100), the dose would be higher because radionuclides from facilities such as the Main Plant Process Building could then migrate towards receptors and reach them sooner with less radioactive decay having taken place. For the Sitewide Close-In-Place Alternative, the SDA is the largest contributor to the long-term dose, while for the No Action Alternative the Waste Tank Farms would dominate.

H.2.2.3.2 Loss of Institutional Controls Leading to North and South Plateau Intruders

This section presents the estimated doses to a spectrum of intruders that could enter the site in the event of failure of institutional controls designed to limit site access. These scenarios are considered to be reasonably conservative ones and useful for understanding the potential magnitude of impacts if intruders come onto the plateaus. The specific intruders evaluated are: (1) direct intruder workers, (2) a resident farmer who has waste material directly deposited in his garden as a result of well drilling or home construction, and (3) a resident farmer who uses contaminated groundwater. Direct intruders are assumed to be located directly above the waste in each WMA while contaminated groundwater is assumed to come from wells that are located approximately 100 meters downgradient from the edge of the waste, see Figure H–3. Additional information on these exposure scenarios is provided in Appendix D. For the purposes of analysis of the No Action alternative, the Main Plant Process Building, the Vitrification Facility, and the Waste Tank Farm are assumed to have collapsed and lost their structural integrity after exactly 100 years.

Intruder Worker

Table H–44 presents the doses to the intruder worker. Two worker scenarios were considered, a well driller and a home constructor. For the well driller, exposure pathways include inadvertent ingestion of contaminated soil, inhalation of contaminated dust, and direct exposure to contaminated water in a cuttings pond. For home construction, exposure pathways include inadvertent ingestion of contaminated soil, inhalation of contaminated dust, and exposure to external radiation from the walls of an excavation for the foundation of a home. However, the home construction scenario is not considered credible when there is a thick engineered cap (e.g., the South Plateau burial grounds under the Sitewide Close-In-Place Alternative).

The results of this analysis are summarized in Table H–44, with the results presented for the scenario with the highest TEDE. The results presented assume the scenario occurs after 100 years of effective institutional controls.

Under the Sitewide Close-In-Place Alternative, none of the predicted doses would exceed 10 millirem per year.[10] However, the No Action Alternative peak annual doses could be substantial. For the No Action Alternative, the highest dose would be for the Low-Level Waste Treatment Facility from the home construction scenario. In all cases, the radionuclide contributing the greatest portion of dose is cesium-137.

This analysis shows the importance of the thick, multi-layered engineered barrier in limiting the extent of direct intrusion into the waste, and thereby limiting the dose under the Sitewide Close-In-Place Alternative.

[10] *This is merely an observation with no implied regulatory implications.*

Table H–44 Estimated Peak Total Effective Dose Equivalent in Millirem Per Year to Intruder Worker (well driller or home construction worker) – Intrusion After 100 Years

Waste Management Areas	*Sitewide Close-In-Place Alternative*	*No Action Alternative*
Main Plant Process Building – WMA 1	Not applicable	3,890 [a,c]
Vitrification Facility – WMA 1	Not applicable	27,800 [a,c]
Low-Level Waste Treatment Facility – WMA 2	1.7 [d]	55,700 [a,c]
Waste Tank Farm – WMA 3	Not applicable	133 [d]
NDA – WMA 7	Not applicable	18,900 [a]
SDA – WMA 8	Not applicable	4,580 [a,c]
North Plateau Groundwater Plume	0 [b]	0 [b]
Cesium Prong Onsite	4.4 [c]	4.4 [c]
Cesium Prong Offsite	0.9 [c]	0.9 [c]

NDA = NRC-licensed Disposal Area, SDA = State-licensed Disposal Area, WMA = Waste Management Area.

[a] The doses for the No Action alternative are very high because, in this scenario, the well driller or home construction worker intrudes directly into volumes that contain high inventories of radionuclides. In the corresponding Sitewide Close-In-Place scenarios, the concentrated inventories have been covered by a cap that is thick enough to preclude a home construction worker from reaching the remaining inventories.

[b] There would be a dose to a well driller, but it is predicted to be less than 1×10^{-8} millirem per year.

[c] Peak impact due to home construction scenarios.

[d] Peak impact due to well-drilling scenarios.

Resident Farmer with Waste Material in His Garden

Table H–45 presents the doses to the resident farmer as a result of direct contact from contamination that would be brought to the surface and placed in a garden following a well drilling or home construction scenario. In all cases, the radionuclide contributing the greatest portion of dose is cesium-137.

Table H–45 Estimated Peak Total Effective Dose Equivalent in Millirem Per Year to Resident Farmer with a Garden Containing Contaminated Soil from Well Drilling or House Construction – Intrusion After 100 Years

Waste Management Areas	*Sitewide Close-In-Place Alternative*	*No Action Alternative*
Main Plant Process Building – WMA 1	Not applicable	7,350 [a,c]
Vitrification Facility – WMA 1	Not applicable	71,800 [a,c]
Low-Level Waste Treatment Facility – WMA 2	12 [b,d]	111,000 [a,c,]
Waste Tank Farm – WMA 3	Not applicable	2,030 [a,c]
NDA – WMA 7	Not applicable	22,600 [a,d]
SDA – WMA 8	Not applicable	2,750 [a,c]
North Plateau Groundwater Plume	0 [d]	0 [d]
Cesium Prong – onsite	4.4 [c]	4.4 [c]
Cesium Prong – offsite	0.9 [c]	0.9 [c]

NDA = NRC-licensed Disposal Area, SDA = State-licensed Disposal Area, WMA = Waste Management Area.

[a] The doses for the No Action Alternative are very high because, in this scenario, the well driller or home construction worker intrudes directly into volumes that contain high inventories of radionuclides. In the corresponding Sitewide Close-In-Place scenarios, the concentrated inventories have been covered by a cap that is thick enough to preclude a home construction worker from reaching the remaining inventories.

[b] In the case of the Low-Level Waste Treatment Facility, it is possible for the well driller to penetrate soil contaminated with radioactive waste, and spread radioactive material over a farmer's garden. However, the amount of material brought to the surface by a well driller is much less than that spread around during house construction.

[c] Peak impact due to home construction scenarios

[d] Peak impact due to well-drilling scenarios.

Resident Farmer Using Contaminated Groundwater

Table H–46 presents the doses to the resident farmer whose contact with the waste would be through an indirect pathway – the use of contaminated water. The receptors for the North Plateau facilities (Main Plant Process Building, Low-Level Waste Treatment Facility, Waste Tank Farm, and North Plateau Groundwater Plume) have wells in the sand and gravel layer on the North Plateau. For the North Plateau Groundwater Plume, the peak dose for the Sitewide Close-In-Place Alternative exceeds that of the No Action Alternative because the plume moves more rapidly for the No Action Alternative. The scenario is inapplicable for the NDA and SDA receptor because of the low hydraulic conductivity of the unweathered Lavery until and the unsaturated conditions in the Kent Recessional Sequence.

Table H–46 Estimated Peak Total Effective Dose Equivalent in Millirem Per Year to a Resident Farmer using Contaminated Groundwater – Intrusion After 100 Years

Waste Management Areas	*Sitewide Close-In-Place Alternative*	*No Action Alternative*
Main Plant Process Building – WMA 1	366	36,900 [a]
Vitrification Facility – WMA 1	1.9	3,410 [a]
Low-Level Waste Treatment Facility – WMA 2	110	3,000
Waste Tank Farm – WMA 3	556	1,500,000 [a]
NDA – WMA 7	Not applicable	Not applicable
SDA – WMA 8	Not applicable	Not applicable
North Plateau Groundwater Plume	846	420
Cesium Prong – onsite	4.4	4.4
Cesium Prong – offsite	0.9	0.9

NDA = NRC-licensed Disposal Area, SDA = State-licensed Disposal Area, WMA = Waste Management Area.
[a] The doses for the No Action Alternative are very high because, in this scenario, the well intrudes directly into volumes that contain high inventories of radionuclides. In the Sitewide Close-In-Place scenario the cap prevents direct intrusion into the waste and the slurry wall and cap limit flow of water through the waste.

The results for the No Action Alternative clearly show that serious consequences are possible should facilities like the Main Plant Process Building or the Waste Tank Farm be abandoned. The results also show the high potential consequences for both alternatives in the event of intrusion over the North Plateau Groundwater Plume.

The time series of dose for the North Plateau plume under the Sitewide Close-In-Place Alternative is presented in **Figure H–12** for receptors at 100 and 300 meters from the source of the plume. The figure illustrates how sensitive the dose is to the time at which the intrusion occurs, and to where the intruder places his farm. The peak dose in Table H–46 for the North Plateau Groundwater Plume for the Sitewide Close-In-Place Alternative come from the receptor at 300 meters at 100 years. The distance of 100 meters is in the vicinity of the peak concentration of the plume at the first year of the period of analysis for both the No Action and Sitewide Close-In-Place Alternatives and just outside of the downgradient slurry wall for the Sitewide Close-In-Place Alternative. The distance of 300 meters is located just upgradient of the North Plateau drainage ditch, the first location of discharge of the plume to the surface. For each alternative, the peak onsite concentration would occur during the period of institutional control when a receptor could not access the contaminated groundwater. As time proceeds, concentration in the plume decreases at locations near the source and increases and then decreases at locations further removed from the source. This behavior explains the occurrence of peak dose at a location removed from the original source for an analysis time of 100 years.

Dose from Multiple Sources

The previous discussion presented information on the dose to various receptors from individual WMAs. There is the potential for receptors to come in contact with contamination from multiple areas and therefore see higher doses than one would see from a single WMA. The highest doses are home construction intruders for the No Action Alternative (Table H–44), a resident farmer with contamination from home construction for the No Action Alternative (Table H–45) and a resident farmer using contaminated groundwater under either the Sitewide Close-In-Place Alternative or the No Action Alternative (Table H–46).

The greatest potential for a dose from multiple sources for the No Action Alternative would be the combination of a garden contaminated with material from a home construction and irrigated with contaminated groundwater. These combinations could result in peak doses approaching 100,000 millirem or even higher if the well was located near the Waste Tank Farm.

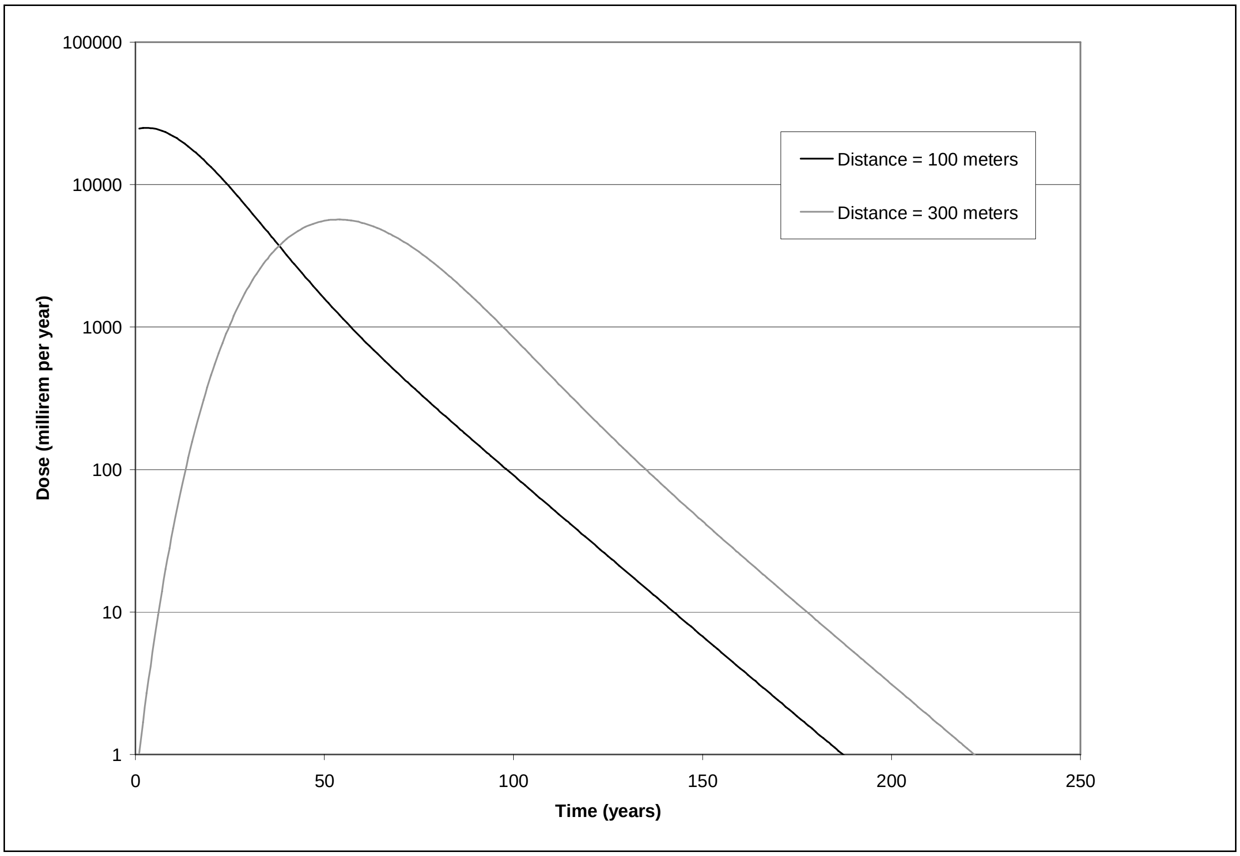

Figure H–12 Time Series of Dose for Onsite Receptors for North Plateau Groundwater Plume Under Sitewide Close-In-Place – Time Measured from Completion of Decommissioning

The greatest potential for the Sitewide Close-In-Place Alternative would appear to involve a water well on the North Plateau that would intercept the plume from both the Main Plant Process Building and the Waste Tank Farm. A conservative estimate of the combined dose from the Main Plant Process Building and the Waste Tank Farm would be about 900 millirem (366 from the Main Plant Process Building and 556 from Waste Tank Farm).

H.2.2.3.3 Effect of Loss of Institutional Controls on Offsite Receptors

This Section is parallel to Section H.2.2.2, which presented the results of the long-term performance assessment for offsite receptors assuming indefinite continuation of institutional controls (but with no erosion, which is considered in Section H.2.2.4). However, in this Section it is assumed that institutional controls will be lost after 100 years and maintenance activities will cease. In particular, it is assumed that there are no more efforts to contain radionuclides and hazardous chemicals within WMAs on the North and South Plateaus. Conservatively, these are assumed to fail as soon as institutional controls fail. This subsection reexamines the analysis for the offsite receptors.

The principal effect of allowing releases from the Main Plant Process Building, the Vitrification Facility, and the Waste Tank Farm is to considerably increase predicted doses and risks for the No Action Alternative. However, the predicted doses and risks for the Sitewide Close-In-Place Alternative are barely changed because the various engineered features that would be put in place around and above (for example) the NDA and SDA would be little affected by the cessation of maintenance. Therefore, the discussion in Section H.2.2.2.3 focuses on the No Action Alternative. Tabular results for the Sitewide Close-In-Place Alternative are included for comparison, but readers should turn to Section H.2.2.1 for discussions.

Cattaraugus Creek Receptor

As described previously, the Cattaraugus Creek receptor is a postulated offsite receptor who is closest to the site boundary and receives the impact of liquid release from all portions of the site. This receptor is conservatively assumed to drink water from Cattaraugus Creek, eat fish and deer, and irrigate his garden, also with water from Cattaraugus Creek.

Radiological Dose and Risk

This section covers TEDE, dominant doses and pathways, and radiological risk.

Total Effective Dose Equivalent

Figure H–13 present the annual TEDE as a function of time to the Cattaraugus Creek receptor for the No Action Alternative. See Figure H–4 for the comparable plot for the Sitewide Close-In-Place Alternative.

The figures show a number of peaks that correspond to the arrival of "pulses" of radionuclides from different areas on the site. This is further clarified by **Table H–47**, which, for each alternative, displays the WMA, the predicted peak annual TEDE arising from radionuclides leaching from the WMA, and the predicted years until peak annual TEDE.

The results presented in Table H–47 show that the total peak annual dose to the Cattaraugus Creek receptor due to groundwater releases would s be below 25 millirem per year for both alternatives. However, whereas in Table H–26 the predicted total doses for the two alternatives were about the same, the dose for the No Action Alternative is now 40 to 50 times larger. For the No Action Alternative, the peak annual dose would be dominated by the Waste Tank Farm and occurs at approximately 100 years. The dominant radionuclide from the Waste Tank Farm is strontium-90 in drinking water. The doses for the Sitewide Close-In-Place Alternative are much the same as they were for indefinite continuation of institutional controls, reflecting the fact that the conservative assumptions in the model mean that the maintenance or cessation of institutional controls make little difference to how rapidly, for example, nuclides enter groundwater in the SDA and are then transported to Franks Creek or Erdman Brook.

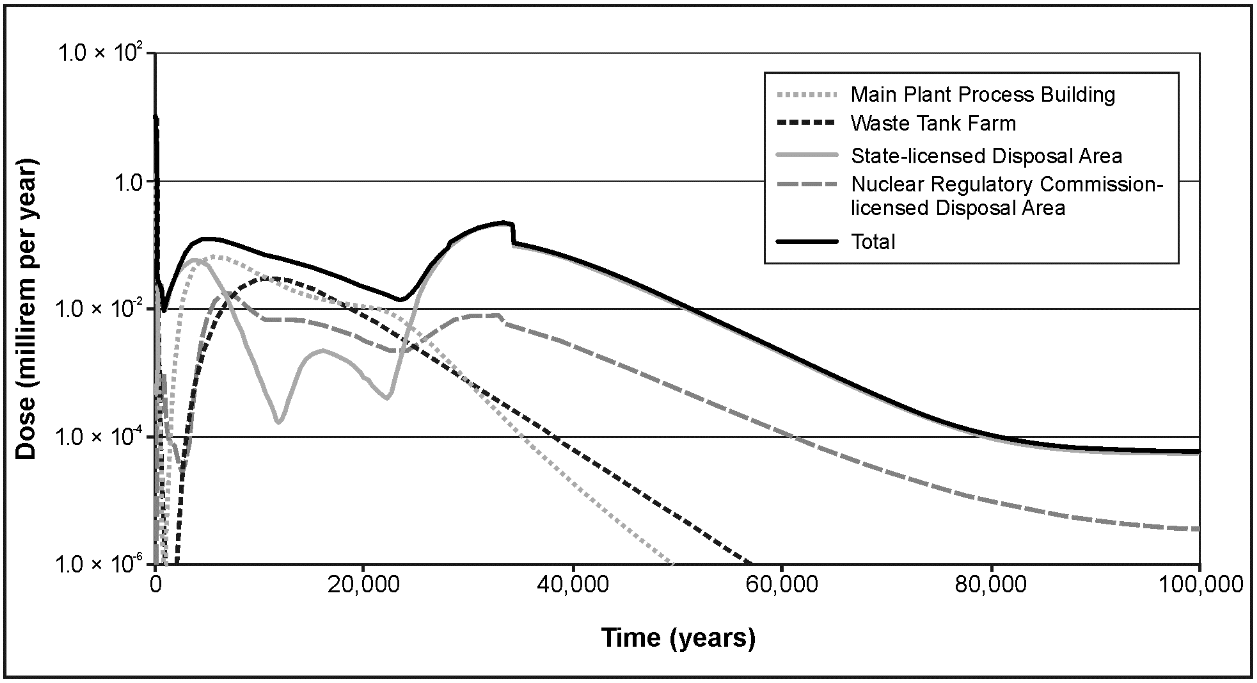

Figure H–13 Annual Total Effective Dose Equivalent for the Cattaraugus Creek Receptor with the No Action Alternative and Loss of Institutional Controls after 100 Years

Table H–47 Peak Annual Total Effective Dose Equivalent in Millirem Per Year for the Cattaraugus Creek Receptor (year of peak exposure in parentheses) – Loss of Institutional Controls After 100 Years

Waste Management Areas [a]	*Sitewide Close-In-Place Alternative*	*No Action Alternative*
Main Plant Process Building – WMA 1	0.019 (200)	1.3 (100) [b]
Vitrification Facility – WMA 1	0.000082 (500)	0.23 (100) [b]
Low-Level Waste Treatment Facility – WMA 2	0.0092 (100)	0.026 (100)
Waste Tank Farm – WMA 3	0.0029 (200)	8.9 (100) [b]
NDA – WMA 7	0.018 (6,800) [c]	0.018 (6,800) [c]
SDA – WMA 8	0.21 (33,800) [c]	0.21 (33,800) [c]
North Plateau Groundwater Plume	0.072 (79)	0.11 (68)
Total	0.22 (33,700)	10 (100)

NDA = NRC-licensed Disposal Area, SDA = State-licensed Disposal Area, WMA = Waste Management Area.

[a] For WMAs 1 through 3, the contributions to dose are presented for the key facilities that contain almost all of the radioactive materials in the WMA. However, no single facility characterizes the burial grounds, so the NDA (WMA 7) and the SDA (WMA 8) are presented as entities in their own right. Other WMAs are not sources of radioactive materials.

[b] It is assumed that maintenance actions would keep engineered systems (caps, drying systems, roofs, etc.) operational for 100 years. The doses from these units would be minimal as long as these engineered systems function as originally designed.

[c] The reason why the predicted population doses and years until peak exposure are approximately the same for the Sitewide Close-In-Place and No Action Alternatives is that it is assumed that the effectiveness of any caps and other mitigating features in the Sitewide Close-In-Place Alternative degrades immediately so that groundwater flow rates and leaching rates are essentially the same for both alternatives.

Detailed Analysis of Total Effective Dose Equivalent

Table H–48 provides further detailed breakdown of Table H–47 organized by components. The parallel table in Section H.2.2.2 is Table H–27.

Table H–48 shows that the dominant contributor to the radiological dose for the No Action Alternative is Tank 8D-2

Table H–48 Peak Annual Total Effective Dose Equivalent in Millirem Per Year for the Cattaraugus Creek Receptor Broken Down by Waste Management Area Components (year of peak exposure in parentheses) – Loss of Institutional Controls After 100 Years

Waste Management Areas [a]	*Waste Management Area Components*	*Sitewide Close-In-Place Alternative*	*No Action Alternative*
Main Plant Process Building – WMA 1	Rubble Pile	1.4×10^{-3} (800)	2.0×10^{-1} (100) [b]
	General Purpose Cell	6.8×10^{-3} (19,700)	6.0×10^{-1} (100) [b]
	Liquid Waste Cell	1.4×10^{-2} (200)	4.7×10^{-1} (100) [b]
	Fuel Receiving Storage Pad	3.3×10^{-4} (19,800)	2.6×10^{-2} (100) [b]
	Total Main Plant Process Building	1.9×10^{-2} (200)	1.3 (100) [b]
Vitrification Facility – WMA 1		8.2×10^{-5} (500)	2.3×10^{-1} (100) [b]
Low-Level Waste Treatment Facility – WMA 2	Lagoon 1	1.0×10^{-4} (6,500)	6.9×10^{-3} (100)
	Lagoon 2	5.5×10^{-5} (100)	2.3×10^{-3} (100)
	Lagoon 3	1.5×10^{-7} (300)	5.0×10^{-6} (100)
	Lagoon 4	6.2×10^{-7} (100)	6.8×10^{-7} (100)
	Lagoon 5	2.0×10^{-7} (100)	2.3×10^{-7} (100)
	Total LLWTF	1.5×10^{-4} (100)	9.2×10^{-3} (100)
Waste Tank Farm – WMA 3	8D-1	1.6×10^{-3} (200)	4.1×10^{-1} (100) [b]
	8D-2	1.4×10^{-3} (200)	7.0 (100) [b]
	8D-3	6.4×10^{-7} (400)	2.5×10^{-4} (100) [b]
	8D-4	2.5×10^{-5} (400)	1.5 (100) [b]
	Total Waste Tank Farm	2.9×10^{-3} (200)	8.9 (100) [b]
NDA – WMA 7 Horizontal	Process	1.7×10^{-3} (18,500)	2.0×10^{-3} (15,400)
	Hulls	2.8×10^{-4} (12,500)	4.2×10^{-4} (10,700)
	WVDP	1.4×10^{-5} (16,900)	1.5×10^{-5} (14,700)
	Total NDA – Horizontal	2.0×10^{-3} (18,300)	2.3×10^{-3} (14,900)
NDA – WMA 7 Vertical/ Horizontal	Process	7.1×10^{-3} (30,900)	7.1×10^{-3} (31,700)
	Hulls	1.8×10^{-2} (6,800)	1.8×10^{-2} (6,800)
	WVDP	1.2×10^{-4} (21,300)	1.2×10^{-4} (21,300)
	Total NDA – Vertical/Horizontal	1.8×10^{-2} (6,800)	1.8×10^{-2} (6,800)
Total NDA	Total NDA	1.8×10^{-2} (6,800) [c]	1.8×10^{-2} (6,800) [c]
SDA – WMA 8	Horizontal	4.6×10^{-2} (4,700)	4.6×10^{-2} (4,500)
	Vertical/Horizontal	2.1×10^{-1} (33,700)	2.1×10^{-1} (33,700)
	Total SDA	2.1×10^{-1} (33,800) [c]	2.1×10^{-1} (33,800) [c]
North Plateau Groundwater Plume		7.2×10^{-2} (79)	1.1×10^{-1} (68)
Total Site		2.2×10^{-1} (33,700)	1.0×10^{1} (100)

WMA = Waste Management Area, LLWTF = Low-Level Waste Treatment Facility, NDA = NRC-licensed Disposal Area, WVDP = West Valley Demonstration Project, SDA = State-licensed Disposal Area.

[a] For WMAs 1 through 3, the contributions to dose are presented for the key facilities that contain almost all of the radioactive materials in the WMA. However, no single facility characterizes the burial grounds, so the NDA (WMA 7) and the SDA (WMA 8) are presented as entities in their own right. Other WMAs are not sources of radioactive materials.

[b] It is assumed that maintenance actions would keep engineered systems (caps, drying systems, roofs, etc.) operational for 100 years. The doses from these units would be minimal as long as these engineered systems function as originally designed.

[c] The reason why the predicted TEDEs and years until peak exposure are the same for the Sitewide Close-In-Place and No Action Alternatives is that it is assumed that the effectiveness of any caps and other mitigating features in the Sitewide Close-In-Place Alternative degrades immediately so that groundwater flow rates and leaching rates are essentially the same for both alternatives.

Controlling Nuclides and Pathways

It is of interest to understand the controlling nuclides and pathways at the years until peak TEDE. **Table H–49** provides this information. For the No Action Alternative, also as noted above, the high-level waste tanks, particularly 8D-2 provide the largest peaks. These are dominated by the ingestion of strontium-90 in drinking water, whereas the Sitewide Close-In-Place Alternative is dominated by uranium and carbon isotopes from the SDA via fish.

Table H–49 Controlling Nuclides and Pathways for the Cattaraugus Creek Receptor, Broken Down by Waste Management Area Components at Year of Peak Annual Total Effective Dose Equivalent – Loss of Institutional Controls After 100 Years

Waste Management Areas [a]	*Waste Management Area Components*	*Controlling Nuclide/Pathway*	
		Sitewide Close-In-Place Alternative	*No Action Alternative*
Main Plant Process Building – WMA 1	Rubble Pile	Iodine-129/Fish	Strontium-90/DW
	General Purpose Cell	Plutonium-239/Fish	Strontium-90/DW
	Liquid Waste Cell	Iodine-129/Fish	Strontium-90/DW
	Fuel Receiving Storage Pad	Plutonium-239/Fish	Strontium-90/DW
Vitrification Facility – WMA 1		Neptunium-237/Fish	Strontium-90/DW
Low-Level Waste Treatment Facility – WMA 2	Lagoon 1	Iodine-129/Fish	Strontium-90/DW
	Lagoon 2	Strontium-90/DW	Strontium-90/DW
	Lagoon 3	Uranium-234/DW	Uranium-234/DW
	Lagoon 4	Uranium-234/DW	Uranium-234/DW
	Lagoon 5	Uranium-234/DW	Uranium-234/DW
Waste Tank Farm – WMA 3	8D-1	Technetium-99/RF [b]	Strontium-90/DW
	8D-2	Technetium-99/Fish	Strontium-90/DW
	8D-3	Technetium-99/RF [b]	Strontium-90/DW
	8D-4	Iodine-129/Fish	Strontium-90/DW
NDA – WMA 7 Horizontal	Process	Uranium-233/DW	Uranium-233/DW
	Hulls	Carbon-14/Fish	Carbon-14/Fish
	WVDP	Uranium-233/DW	Uranium-233/DW
NDA – WMA 7 Vertical/Horizontal	Process	Uranium-233/DW	Uranium-233/DW
	Hulls	Carbon-14/Fish	Carbon-14/Fish
	WVDP	Uranium-233/DW	Uranium-233/DW
SDA – WMA 8	Horizontal	Uranium-234/Fish	Uranium-234/Fish
	Vertical/Horizontal	Uranium-234/Fish	Uranium-234/Fish
North Plateau Groundwater Plume		Strontium-90/DW	Strontium-90/DW

DW = drinking water, NDA = NRC-licensed Disposal Area, RF = resident farmer, SDA = State-licensed Disposal Area, WVDP = West Valley Demonstration Project, WMA = Waste Management Area.

[a] For WMAs 1 through 3, the contributions to dose are presented for the key facilities that contain almost all of the radioactive materials in the WMA. However, no single facility characterizes the burial grounds, so the NDA (WMA 7) and the SDA (WMA 8) are presented as entities in their own right. Other WMAs are not sources of radioactive materials.

[b] RF means resident farmer and includes a number of pathways such as eating contaminated vegetables, inhalation, etc.

Excess Cancer Risk

A complementary measure is the peak lifetime risk (excess cancer risk) to the Cattaraugus Creek receptor arising from radiological discharges. **Table H–50** shows how this risk varies from different WMAs and what it is for contributions from the entire WNYNSC for each alternative. As expected, this table closely parallels the dose table, Table H–47. Releases from the Main Plant Process Building, the Vitrification Facility, and the Waste Tank Farms increase the predicted lifetime risk of cancer fatality by about a factor of 100 to ~ 10^{-4}.

Table H–50 Peak Lifetime Radiological Risk (risk of latent cancer morbidity) for the Cattaraugus Creek Receptor (year of peak risk in parentheses) – Loss of Institutional Controls After 100 Years

Waste Management Areas [a]	*Sitewide Close-In-Place Alternative*	*No Action Alternative*
Main Plant Process Building – WMA 1	3.6×10^{-7} (200)	2.8×10^{-5} (100) [b]
Vitrification Facility – WMA 1	5.0×10^{-10} (500)	5.0×10^{-6} (100) [b]
Low-Level Waste Treatment Facility – WMA 2	3.9×10^{-9} (100)	2.0×10^{-7} (100)
Waste Tank Farm – WMA 3	1.3×10^{-7} (200)	1.9×10^{-4} (100) [b]
NDA – WMA 7	4.7×10^{-7} (6,800) [c]	4.7×10^{-7} (6,800) [c]
SDA – WMA 8	2.7×10^{-6} (33,700) [c]	2.7×10^{-6} (33,700) [c]
North Plateau Groundwater Plume	1.6×10^{-6} (79)	2.4×10^{-6} (68)
Total	2.7×10^{-6} (33,700)	2.3×10^{-4} (100)

NDA = NRC-licensed Disposal Area, SDA = State-licensed Disposal Area, WMA = Waste Management Area.
[a] For WMAs 1 through 3, the contributions to dose are presented for the key facilities that contain almost all of the radioactive materials in the WMA. However, no single facility characterizes the burial grounds, so the NDA (WMA 7) and the SDA (WMA 8) are presented as entities in their own right. Other WMAs are not sources of radioactive materials.
[b] It is assumed that maintenance actions would keep engineered systems (caps, drying systems, roofs, etc.) operational for 100 years. The risks from these units would be minimal as long as these engineered systems function as originally designed.
[c] The reason why the predicted risks and years until peak exposure are the same for the Sitewide Close-In-Place and No Action Alternatives is that it is assumed that the effectiveness of any caps and other mitigating features in the Sitewide Close-In-Place Alternative degrades immediately so that groundwater flow rates and leaching rates are essentially the same for both alternatives.

Hazardous Chemical Risk

Estimates of the risk to the Cattaraugus Creek receptor from hazardous chemicals in the burial grounds, the process building and the high-level waste tank have also been prepared. Three measures are used: lifetime cancer risk, hazard index and comparison to MCLs for drinking water that have been issued under the Clean Water Act.

Lifetime Cancer Risk

Table H–51 shows the peak lifetime cancer risk from chemical exposure broken down by WMA. In contrast to the case for radiological doses, the additional releases from the Main Plant Process Building and Waste Tank Farm that occurring the case of the No Action Alternative do not cause a large increase in risk. This is because, when thinking purely of chemicals, inventories of hazardous chemicals are much larger and more mobile in the NDA and SDA than in the buildings and tanks.[11]

[11] Note that, in general, organic chemicals experience less retardation than radionuclides. The controlling constituent of the NDA impact is more strongly retarded than that for the SDA impact, which is why the SDA peak occurs much earlier than the NDA peak. Note also that degradation of organic compounds was not addressed.

Table H–51 Peak Lifetime Risk from Hazardous Chemicals (risk of latent cancer morbidity) for the Cattaraugus Creek Receptor (year of peak risk in parentheses) – Loss of Institutional Controls After 100 Years

Waste Management Areas [a]	*Sitewide Close-In-Place Alternative*	*No Action Alternative*
Main Plant Process Building – WMA 1	1.3×10^{-10} (6,000)	2.9×10^{-9} (4,200) [b]
Vitrification Facility – WMA 1	5.9×10^{-11} (7,400)	1.0×10^{-9} (4,300) [b]
Waste Tank Farm – WMA 3	3.1×10^{-10} (9,000)	1.0×10^{-9} (2,600) [b]
NDA – WMA 7	1.3×10^{-9} (86,400) [c]	1.3×10^{-9} (88,700) [c]
SDA – WMA 8	2.0×10^{-8} (100) [c]	2.1×10^{-8} (100) [c]
Total	2.0×10^{-8} (100)	2.1×10^{-8} (100)

NDA = NRC-licensed Disposal Area, SDA = State-licensed Disposal Area, WMA = Waste Management Area.

[a] The limited information available on hazardous chemical inventories in the Low-Level Waste Treatment Facility suggest it will not make a noticeable contribution to the overall long-term risk from hazardous chemicals.

[b] It is assumed that maintenance actions would keep engineered systems (caps, drying systems, roofs, etc.) operational for 100 years. The risk from these units would be minimal as long as these engineered systems function as originally designed.

[c] The reason why the predicted risks and years until peak exposure are the same for the Sitewide Close-In-Place and No Action Alternatives is that it is assumed that the effectiveness of any caps and other mitigating features in the Sitewide Close-In-Place Alternative degrades immediately so that groundwater flow rates and leaching rates are essentially the same for both alternatives.

This comparison of lifetime cancer risk from radionuclides and chemicals for the Cattaraugus Creek receptor in the No Action Case is also shown in **Figure H–14**. The comparable figure for the No Action Alternative with indefinite continuation of institutional controls is given in Figure H–7. The two figures are similar.

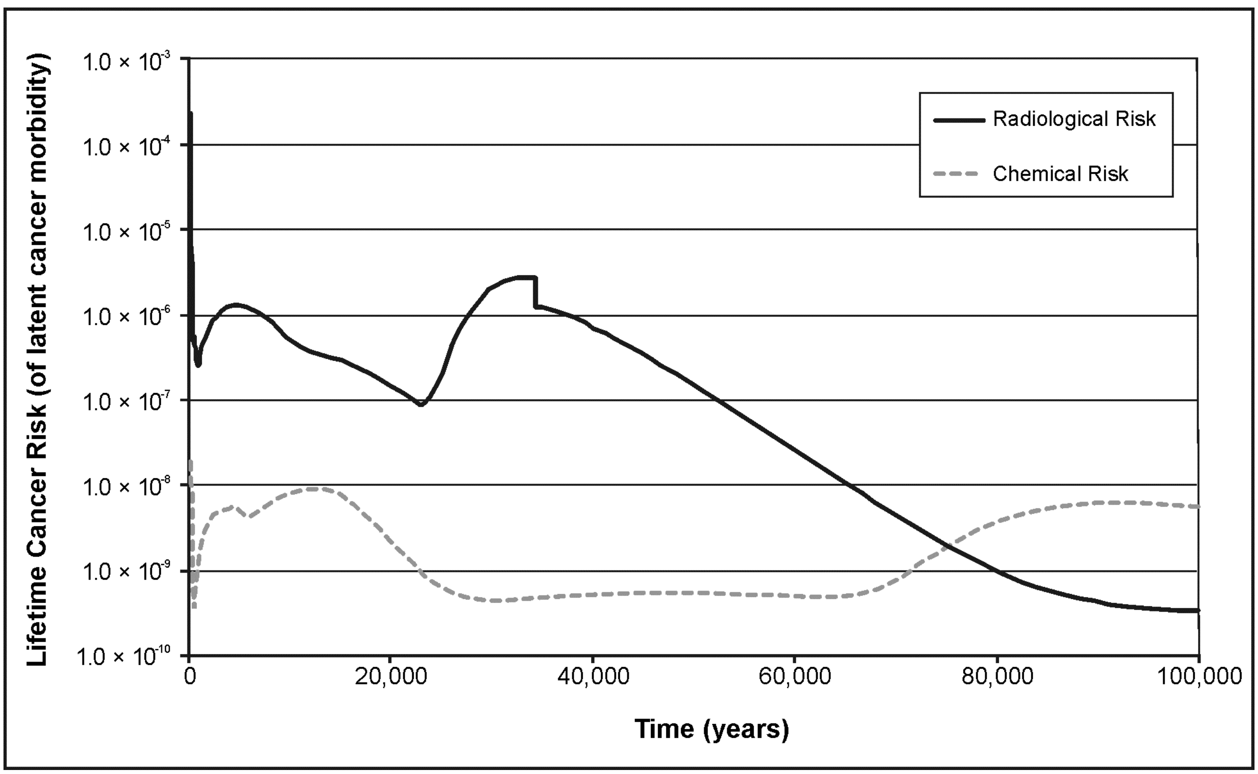

Figure H–14 Lifetime Cancer Risk from Radionuclides and Hazardous Chemicals for the Cattaraugus Creek Receptor with the No Action Alternative and Loss of Institutional Controls After 100 Years

As was the case for TEDEs (Table H–48), it is possible to break the information in Table H–51 down to more detailed levels. However, the contributions from all sources are so small that it is not worth breaking them down further. It is also possible to graphically represent how the excess cancer risks listed above behave as a function of time, broken down by each WMA. These detailed results are available upon request.

Hazard Index

Another measure of chemical risk that is appropriate for non-carcinogenic chemicals is the hazard index for an individual receptor. If the hazard index is greater than 1, an observable non-carcinogenic health effect may occur. **Table H–52** presents the hazard index peaks for the Cattaraugus Creek receptor in the case of loss of institutional controls after 100 years.

These hazard indices are all very small, with the totals being less than 1 percent. The Main Plant Process Building and the Vitrification Facility add only about 20 percent to the total hazard index. In principal, they can be broken down by WMA component. Their behavior as a function of time could also be plotted. However, this would not provide much useful information since the totals are so small. These breakdowns are available upon request.

Table H–52 Peak Chemical Hazard Index for the Cattaraugus Creek Receptor (year of peak hazard index in parentheses) – Loss of Institutional Controls After 100 Years

Waste Management Areas [a]	*Sitewide Close-In-Place Alternative*	*No Action Alternative*
Main Plant Process Building – WMA 1	6.7×10^{-6} (8,100)	1.1×10^{-4} (3,300) [b]
Vitrification Facility – WMA 1	2.5×10^{-6} (10,100)	3.8×10^{-5} (4,400) [b]
Waste Tank Farm – WMA 3	2.0×10^{-4} (12,400)	6.7×10^{-4} (3,600) [b]
NDA – WMA 7	1.4×10^{-5} (30,100)	1.5×10^{-5} (30,900)
SDA – WMA 8	2.8×10^{-3} (4,700)	2.9×10^{-3} (4,500)
Total	2.9×10^{-3} (4,700)	3.6×10^{-3} (4,300)

NDA = NRC-licensed Disposal Area, SDA = State-licensed Disposal Area, WMA = Waste Management Area.
[a] The limited information available on hazardous chemical inventories in the Low-Level Waste Treatment Facility suggest it will not make a noticeable contribution to the overall long-term risk from hazardous chemicals.
[b] It is assumed that maintenance actions would keep engineered systems (caps, drying systems, roofs) operational for 100 years. The hazard indices from these units would be minimal as long as these engineered systems function as originally designed.

Fraction of Maximum Concentration in Liquid

Table H–53 shows the chemical that has the largest fraction of its MCL at the years until peak risk and the years until peak hazard index. The addition of releases from the Main Plant Process Building and the Waste Tank Farm for the No Action Alternative does not change the conclusion that the maximum ratios to the MCL are all less than one, nor does it introduce different chemicals.

Seneca Nation of Indians Receptor

As described previously, the Seneca Nation of Indians receptor is similar to the Cattaraugus Creek receptor but is postulated to consume a larger amount of fish (62 kilograms per year) raised in the lower reaches of Cattaraugus Creek or in Lake Erie near the point where Cattaraugus Creek discharges into the lake. The results presented below are in many respects similar to those for the Cattaraugus Creek receptor, so the discussion that follows is less detailed than for Cattaraugus Creek.

Table H–53 Chemicals with Largest Fraction of Maximum Concentration Levels in Cattaraugus Creek – Loss of Institutional Controls After 100 Years [a]

Waste Management Areas [b]	*Sitewide Close-In-Place Alternative*	*No Action Alternative*
Year of Peak Risk in Parentheses		
Main Plant Process Building – WMA 1	9.7×10^{-6} (55,100) Pb [d]	1.9×10^{-4} (4,200) Pb [c,d]
Vitrification Facility – WMA 1	6.7×10^{-3} (40,500) Pb [d]	8.5×10^{-2} (4,300) Tl [c,e]
Waste Tank Farm – WMA 3	2.0×10^{-6} (9,000) Tl [e]	4.8×10^{-6} (2,600) Tl [c,e]
NDA – WMA 7	1.3×10^{-6} (86,700) As [f]	1.3×10^{-6} (89,200) As [f]
SDA – WMA 8	8.3×10^{-5} (200) Usol [g]	9.0×10^{-5} (100) Usol [g]
Year of Peak Hazard Index in Parentheses		
Main Plant Process Building – WMA 1	9.6×10^{-6} (8,100) Pb [d]	1.5×10^{-4} (3,300) Pb [c,d]
Vitrification Facility – WMA 1	6.7×10^{-3} (26,000) Pb [d]	8.5×10^{-2} (4,300) Tl [c,e]
Waste Tank Farm – WMA 3	2.1×10^{-6} (12,400) Tl [e]	7.2×10^{-6} (3,600) Tl [c,e]
NDA – WMA 7	3.4×10^{-5} (30,200) Usol [f,h]	3.4×10^{-5} (31,000) Usol [f,h]
SDA – WMA 8	7.5×10^{-3} (4,700) Usol [g,h]	7.8×10^{-3} (4,500) Usol [g,h]

NDA = NRC-licensed Disposal Area, SDA = State-licensed Disposal Area, WMA = Waste Management Area.

[a] Presented as fraction of the applicable MCL / (years until peak exposure) / chemical.

[b] The limited information available on hazardous chemical inventories in the Low-Level Waste Treatment Facility suggest it will not make a noticeable contribution to the overall long-term risk from hazardous chemicals.

[c] It is assumed that maintenance actions would keep engineered systems (caps, drying systems, roofs) operational indefinitely. The health impacts of hazardous chemicals released from these units would be minimal as long as these engineered systems function as originally designed and institutional controls prevents releases from the Main Plant Process Building, the Vitrification Facility, and the Waste Tank Farm.

[d] Pb = lead, MCL (Action Level) = 0.015 milligrams per liter.

[e] Tl= thallium, MCL = 0.002 milligrams per liter.

[f] As = arsenic, MCL = 0.01 milligrams per liter.

[g] Usol = soluble uranium, MCL = 0.03 milligrams per liter.

[h] The reason why the predicted MCL and years until peak exposure are almost the same for the Sitewide Close-In-Place and No Action Alternatives is that it is assumed that the effectiveness of any caps and other mitigating features in the Sitewide Close-In-Place Alternative degrades immediately so that groundwater flow rates and leaching rates are essentially the same for both alternatives.

Radiological Dose and Risk

Total Effective Dose Equivalent

Figure H–15 presents the annual TEDE as a function of time to a Seneca Nation of Indians receptor located just outside the WNYNSC boundary. This hypothetical individual is postulated to drink water from Cattaraugus Creek, use the water for irrigation and consume fish raised in the Cattaraugus Creek. The principal difference from the Cattaraugus Creek receptor is that the Seneca Nation of Indians receptor consumes more fish. The figures show the relative contributions of the four WMAs that are the largest contributors to the predicted dose (the Main Plant Process Building, the Waste Tank Farm, the NDA, and the SDA). This figure is much the same as the comparable one for Cattaraugus Creek (H–13) except that the curves are somewhat higher due to the aforementioned consumption of fish.

The magnitude and the year of the peak contribution are shown in **Table H–54**.

Comparing with Table H–47, the predicted TEDEs would be higher than those of the Cattaraugus Creek receptor for both alternatives, again due to the aforementioned consumption of fish; the ratio of the dose received by the Seneca Nation of Indians receptor to that received by the Cattaraugus Creek Receptor is 2.5 for the Sitewide Close-In-Place Alternative and 1.3 for the No Action Alternative. These peak doses would occur at approximately the same time as do those for the Cattaraugus Creek receptor, and would be dominated by the SDA for the Sitewide Close-In-Place Alternative, and by the Waste Tank Farm for the No Action Alternative.

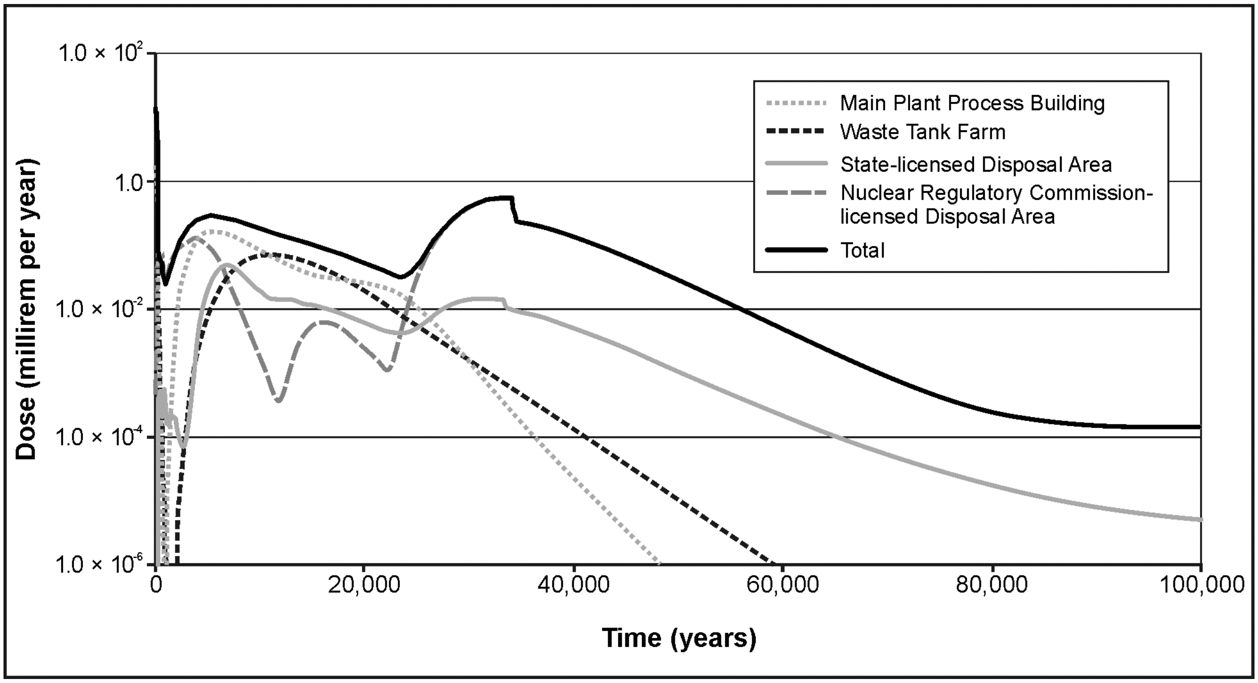

Figure H–15 Annual Total Effective Dose Equivalent for the Seneca Nation of Indians Receptor with the No Action Alternative and Loss Institutional Controls After 100 Years

Table H–54 Peak Annual Total Effective Dose Equivalent in Millirem Per Year for the Seneca Nation of Indians Receptor (year of peak dose in parentheses) – Loss of Institutional Controls After 100 Years

Waste Management Areas [a]	*Sitewide Close-In-Place Alternative*	*No Action Alternative*
Main Plant Process Building – WMA 1	0.052 (200)	1.8 (100) [b]
Vitrification Facility – WMA 1	0.00020 (500)	0.29 (100) [b]
Low-Level Waste Treatment Facility – WMA 2	0.00029 (100)	0.015 (100)
Waste Tank Farm – WMA 3	0.0027 (200)	11 (100) [b]
NDA – WMA 7	0.048 (6,800) [c]	0.049 (6,800) [c]
SDA – WMA 8	0.52 (33,800) [c]	0.52 (33,800) [c]
North Plateau Groundwater Plume	0.093 (78)	0.15 (67)
Total	0.54 (33,700)	13 (100)

NDA = NRC-licensed Disposal Area, SDA = State-licensed Disposal Area, WMA = Waste Management Area.

[a] For WMAs 1 through 3, the contributions to dose are presented for the key facilities that contain almost all of the radioactive materials in the WMA. However, no single facility characterizes the burial grounds, so the NDA (WMA 7) and the SDA (WMA 8) are presented as entities in their own right. Other WMAs are not sources of radioactive materials.

[b] It is assumed that maintenance actions would keep engineered systems (caps, drying systems, roofs, etc.) operational for 100 years. The doses from these units would be minimal as long as these engineered systems function as originally designed.

[c] The reason why the predicted population doses and years until peak exposure are approximately the same for the Sitewide Close-In-Place and No Action Alternatives is that it is assumed that the effectiveness of any caps and other mitigating features in the Sitewide Close-In-Place Alternative degrades immediately so that groundwater flow rates and leaching rates are essentially the same for both alternatives.

Table H–55 provides further detailed breakdown of Table H–54 organized by components of each WMA. Table H–54 is similar to that for the Cattaraugus Creek receptor (Table H–48). Just as was the case for the Cattaraugus Creek receptor, Tank 8D-2 is the dominant contributor to the predicted dose for the No Action Alternative.

Table H–55 Peak Annual Total Effective Dose Equivalent in Millirem Per Year for the Seneca Nation of Indians Receptor Broken down by Waste Management Area Components (year of peak dose in parentheses) – Loss of Institutional Controls After 100 Years

Waste Management Areas [a]	*Waste Management Area Components*	*Sitewide Close-In-Place*	*No Action*
Main Plant Process Building – WMA 1	Rubble Pile	3.5×10^{-3} (800)	2.6×10^{-1} (100) [b]
	General Purpose Cell	1.7×10^{-2} (19,500)	7.7×10^{-1} (100) [b]
	Liquid Waste Cell	3.8×10^{-2} (200)	7.2×10^{-1} (100) [b]
	Fuel Receiving Storage Pool	8.0×10^{-4} (19,800)	3.3×10^{-2} (100) [b]
	Total Main Plant Process Building	5.2×10^{-2} (200)	1.8 (100) [b]
Vitrification Facility – WMA 1		2.0×10^{-4} (500)	2.9×10^{-1} (100)
Low-Level Waste Treatment Facility – WMA 2	Lagoon 1	2.4×10^{-4} (6,500)	1.2×10^{-2} (100)
	Lagoon 2	6.9×10^{-5} (100)	2.8×10^{-3} (100)
	Lagoon 3	2.2×10^{-7} (300)	7.1×10^{-6} (100)
	Lagoon 4	9.1×10^{-7} (100)	1.0×10^{-6} (100)
	Lagoon 5	2.9×10^{-7} (100)	3.4×10^{-7} (100)
	Total Low-Level Waste Treatment Facility	2.9×10^{-4} (100)	1.5×10^{-2} (100)
Waste Tank Farm – WMA 3	8D-1	1.4×10^{-3} (200)	5.1×10^{-1} (100) [b]
	8D-2	1.3×10^{-3} (200)	8.8 (100) [b]
	8D-3	6.0×10^{-7} (400)	3.2×10^{-4} (100) [b]
	8D-4	5.1×10^{-5} (400)	1.9 (100) [b]
	Total Waste Tank Farm	2.7×10^{-3} (200)	1.1×10^{1} (100) [b]
NDA – WMA 7 Horizontal	Process	3.2×10^{-3} (18,500)	3.6×10^{-3} (15,400)
	Hulls	7.4×10^{-4} (12,300)	1.1×10^{-3} (10,600)
	WVDP	2.6×10^{-5} (17,100)	2.8×10^{-5} (14,800)
	Total NDA – Horizontal	3.8×10^{-3} (18,000)	4.5×10^{-3} (14,600)
NDA – WMA 7 Vertical/ Horizontal	Process	1.3×10^{-2} (30,900)	1.3×10^{-2} (31,700)
	Hulls	4.8×10^{-2} (6,800)	4.8×10^{-2} (6,800)
	WVDP	2.3×10^{-4} (21,300)	2.3×10^{-4} (21,300)
	Total NDA – Vertical/ Horizontal	4.8×10^{-2} (6,800)	4.8×10^{-2} (6,800)
Total NDA	Total NDA	4.8×10^{-2} (6,800) [c]	4.9×10^{-2} (6,800) [c]
SDA – WMA 8	Horizontal	9.2×10^{-2} (2,900)	9.5×10^{-2} (2,700)
	Vertical/Horizontal	5.2×10^{-1} (33,800)	5.2×10^{-1} (33,800)
	Total SDA	5.2×10^{-1} (33,800) [c]	5.2×10^{-1} (33,800) [c]
North Plateau Groundwater Plume		9.3×10^{-2} (78)	1.5×10^{-1} (67)
Total Site		5.4×10^{-1} (33,700)	1.3×10^{1} (100)

NDA = NRC-licensed Disposal Area, SDA = State-licensed Disposal Area, WMA = Waste Management Area, WVDP = West Valley Demonstration Project.

[a] For WMAs 1 through 3, the contributions to dose are presented for the key facilities that contain almost all of the radioactive materials in the WMA. However, no single facility characterizes the burial grounds, so the NDA (WMA 7) and the SDA (WMA 8) are presented as entities in their own right. Other WMAs are not sources of radioactive materials.

[b] It is assumed that maintenance actions would keep engineered systems (caps, drying systems, roofs, etc.) operational for 100 years. The doses from these units would be minimal as long as these engineered systems function as originally designed.

[c] The reason why the predicted population doses and years until peak exposure are approximately the same for the Sitewide Close-In-Place and No Action Alternatives is that it is assumed that the effectiveness of any caps and other mitigating features in the Sitewide Close-In-Place Alternative degrades immediately so that groundwater flow rates and leaching rates are essentially the same for both alternatives.

Controlling Nuclides and Pathways

It is of interest to understand the controlling nuclides and pathways at the year of peak TEDE. **Table H–56** provides this information. For the No Action Alternative, also as noted above, the high-level waste tanks, particularly 8D-2 provide the largest peaks. These are dominated by the ingestion of strontium-90 in drinking water, whereas the Sitewide Close-In-Place Alternative is dominated by uranium and carbon isotopes from the SDA via fish ingestion.

Table H–56 Controlling Nuclides and Pathways for the Seneca Nation of Indians Receptor Broken Down by Waste Management Area Components at Year of Peak Total Effective Dose Equivalent – Loss of Institutional Controls After 100 Years

Waste Management Areas [a]	*Waste Management Area Components*	*Sitewide Close-In-Place Alternative*	*No Action Alternative*
Main Plant Process Building – WMA 1	Rubble Pile	Iodine-129/Fish	Strontium-90/Fish
	General Purpose Cell	Plutonium-239/Fish	Strontium-90/Fish
	Liquid Waste Cell	Iodine-129/Fish	Strontium-90/Fish
	Fuel Receiving Storage Pool	Plutonium-239/Fish	Strontium-90/Fish
Vitrification Facility – WMA 1		Neptunium-237/Fish	Strontium-90/Fish
Low-Level Waste Treatment Facility – WMA 2	Lagoon 1	Iodine-129/Fish	Strontium-90/Fish
	Lagoon 2	Strontium-90/Fish	Strontium-90/Fish
	Lagoon 3	Uranium-234/Fish	Uranium-234/Fish
	Lagoon 4	Uranium-234/Fish	Uranium-234/Fish
	Lagoon 5	Uranium-234/Fish	Uranium-234/Fish
Waste Tank Farm – WMA 3	8D-1	Iodine-129/Fish	Strontium-90/Fish
	8D-2	Iodine-129/Fish	Strontium-90/Fish
	8D-3	Iodine-129/Fish	Strontium-90/Fish
	8D-4	Iodine-129/Fish	Strontium-90/Fish
NDA – WMA 7 Horizontal	Process	Uranium-233/Fish	Uranium-233/Fish
	Hulls	Carbon-14/Fish	Carbon-14/Fish
	WVDP	Uranium-233/Fish	Uranium-233/Fish
NDA – WMA 7 Vertical/Horizontal	Process	Uranium-233/Fish	Uranium-233/Fish
	Hulls	Carbon-14/Fish	Carbon-14/Fish
	WVDP	Uranium-233/Fish	Uranium-233/Fish
SDA – WMA 8	Horizontal	Carbon-14/Fish	Carbon-14/Fish
	Vertical/Horizontal	Uranium-234/Fish	Uranium-234/Fish
North Plateau Groundwater Plume		Strontium-90/Fish	Strontium-90/Fish

NDA = NRC-licensed Disposal Area, SDA = State-licensed Disposal Area, WMA = Waste Management Area, WVDP = West Valley Demonstration Project.

[a] For WMAs 1 through 3, the contributions to dose are presented for the key facilities that contain almost all of the radioactive materials in the WMA. However, no single facility characterizes the burial grounds, so the NDA (WMA 7) and the SDA (WMA 8) are presented as entities in their own right. Other WMAs are not sources of radioactive materials.

For the No Action Alternative, the principal difference from Cattaraugus Creek is that the dominant nuclides and pathways for the principal contributor (the Waste Tank Farm) is now strontium-90 via fish rather than via drinking water.

Excess Lifetime Cancer Risk

A complementary measure is the peak lifetime risk to the Seneca Nation of Indians receptor from radiological discharges. **Table H–57** shows how this risk would be apportioned between different WMAs and what it would be for the entire WNYNSC for each alternative. The lifetime radiological cancer risk to the postulated Seneca Nation of Indians receptor is similar to, sometimes slightly higher than, the risk to the Cattaraugus Creek receptor as presented in Table H–50. The higher risk is the result of the postulated higher fish consumption. The radiological risk for the No Action Alternative is dominated by the high-level waste tanks.

Table H–57 Peak Lifetime Radiological Risk (risk of cancer morbidity) for the Seneca Nation of Indians Receptor (year of peak risk in parentheses) – Loss of Institutional Controls After 100 Years

Waste Management Areas [a]	*Sitewide Close-In-Place Alternative*	*No Action Alternative*
Main Plant Process Building – WMA 1	1.0×10^{-6} (200)	4.1×10^{-5} (100) [b]
Vitrification Facility – WMA 1	1.3×10^{-9} (500)	6.6×10^{-6} (100) [b]
Low-Level Waste Treatment Facility – WMA 2	7.2×10^{-9} (100)	3.4×10^{-7} (100)
Waste Tank Farm – WMA 3	9.6×10^{-8} (200)	2.6×10^{-4} (100) [b]
NDA – WMA 7	1.3×10^{-6} (6,800) [c]	1.3×10^{-6} (6,800) [c]
SDA – WMA 8	7.5×10^{-6} (33,800) [c]	7.5×10^{-6} (33,800) [c]
North Plateau Groundwater Plume	2.1×10^{-6} (78)	3.4×10^{-6} (67)
Total	7.6×10^{-6} (33,700)	3.0×10^{-4} (200)

NDA = NRC-licensed Disposal Area, SDA = State-licensed Disposal Area, WMA = Waste Management Area.

[a] For WMAs 1 through 3, the contributions to dose are presented for the key facilities that contain almost all of the radioactive materials in the WMA. However, no single facility characterizes the burial grounds, so the NDA (WMA 7) and the SDA (WMA 8) are presented as entities in their own right. Other WMAs are not sources of radioactive materials.

[b] It is assumed that maintenance actions would keep engineered systems (caps, drying systems, roofs, etc.) operational for 100 years. The risks from these units would be minimal as long as these engineered systems function as originally designed.

[c] The reason why the predicted risks and years until peak exposure are the same for the Sitewide Close-In-Place and No Action Alternatives is that it is assumed that the effectiveness of any caps and other mitigating features in the Sitewide Close-In-Place Alternative degrades immediately so that groundwater flow rates and leaching rates are essentially the same for both alternatives.

Hazardous Chemical Risk

Tables H–46 through H–48 and Figure H–13 show that the lifetime cancer risk from hazardous chemicals, the hazard index, and the ratio of concentration in water to the MCL for the Cattaraugus Creek receptor differ by only about 20 percent whether or not institutional controls are lost. The same conclusion holds for the Seneca Nation of Indians receptor.

Lake Erie/Niagara River Water Users

This section discusses population dose, and individual exposures to radioactive materials and chemicals.

Population Dose

In addition to the Cattaraugus Creek and Seneca Nation of Indians individuals, peak annual and time-integrated population dose estimates have been prepared. These are summarized in **Tables H–58** and **H–59**, respectively. Lake Erie water users consume water taken from Sturgeon Point and several structures in the eastern channel of the Niagara River. They are assumed to drink water from Lake Erie or the Niagara River, to eat fish from Lake Erie, and (conservatively) to all be resident farmers.

Table H–58 Peak Annual Total Effective Population Dose Equivalent in person-rem per year for Lake Erie/Niagara River Water Users (year of peak dose in parentheses) – Loss of Institutional Controls After 100 Years

Waste Management Areas [a]	*Sitewide Close-In-Place Alternative*	*No Action Alternative*
Main Plant Process Building – WMA 1	1.2 (200)	238 (100) [b]
Vitrification Facility – WMA 1	0.0065 (500)	44.3 (100) [b]
Low-Level Waste Treatment Facility – WMA 2	0.02 (100)	1.5 (100)
Waste Tank Farm – WMA 3	0.66 (200)	1,726 (100) [b]
NDA – WMA 7	1.1 (30,600) [c]	1.0 (31,500) [c]
SDA – WMA 8	16.9 (33,700) [c]	16.9 (33,700) [c]
North Plateau Groundwater Plume	13.7 (80)	21.5 (67)
Total	17.9 (33,600)	2,020 (100)

NDA = NRC-licensed Disposal Area, SDA = State-licensed Disposal Area, WMA = Waste Management Area.

[a] For WMAs 1 through 3, the contributions to dose are presented for the key facilities that contain almost all of the radioactive materials in the WMA. However, no single facility characterizes the burial grounds, so the NDA (WMA 7) and the SDA (WMA 8) are presented as entities in their own right. Other WMAs are not sources of radioactive materials.

[b] It is assumed that maintenance actions would keep engineered systems (caps, drying systems, roofs, etc.) operational for 100 years. The risks from these units would be minimal as long as these engineered systems function as originally designed.

[c] The reason why the predicted TEDEs and years until peak exposure are approximately the same for the Sitewide Close-In-Place and No Action Alternatives is that it is assumed that the effectiveness of any caps and other mitigating features in the Sitewide Close-In-Place Alternative degrades immediately so that groundwater flow rates and leaching rates are essentially the same for both alternatives.

Table H–59 Time-Integrated Total Effective Population Dose Equivalent for Lake Erie/Niagara River Water Users (person-rem over 1,000 and 10,000 years) - Loss of Institutional Controls After 100 Years

Waste Management Areas [a]	*Sitewide Close-In-Place Alternative*	*No Action Alternative*
Integration over 1,000 years		
Main Plant Process Building – WMA 1	510	25,000 [b]
Vitrification Facility – WMA 1	4	4,900 [b]
Low-Level Waste Treatment Facility – WMA 2	9	520
Waste Tank Farm – WMA 3	140	220,000 [b]
NDA – WMA 7	140 [c]	140 [c]
SDA – WMA 8	600 [c]	620 [c]
North Plateau Groundwater Plume	730	1,000
Total	2,100	252,000
Integration over 10,000 years		
Main Plant Process Building – WMA 1	1,000	130,000 [b]
Vitrification Facility – WMA 1	5	5,000 [b]
Low-Level Waste Treatment Facility – WMA 2	9	2,400
Waste Tank Farm – WMA 3	270	223,000 [b]
NDA – WMA 7	4,100 [c]	4,400 [c]
SDA – WMA 8	29,000 [c]	29,000 [c]
North Plateau Groundwater Plume	750	1,020
Total	35,000	395,000

NDA = NRC-licensed Disposal Area, SDA = State-licensed Disposal Area, WMA = Waste Management Area.

[a] For WMAs 1 through 3, the contributions to dose are presented for the key facilities that contain almost all of the radioactive materials in the WMA. However, no single facility characterizes the burial grounds, so the NDA (WMA 7) and the SDA (WMA 8) are presented as entities in their own right. Other WMAs are not sources of radioactive materials.

[b] It is assumed that maintenance actions would keep engineered systems (caps, drying systems, roofs) operational for 100 years. The doses from these units would be minimal as long as these engineered systems function as originally designed.

[c] The reason why the predicted population doses are approximately the same for the Sitewide Close-In-Place and No Action Alternatives is that it is assumed that the effectiveness of any caps and other mitigating features in the Sitewide Close-In-Place Alternative degrades immediately so that groundwater flow rates and leaching rates are essentially the same for both alternatives.

As described previously, most of the population dose shown in Table H–58 would be received by the users of water from Sturgeon Point intake which would see higher radionuclide concentrations than the intake structures on the Niagara River. The estimated annual background radiation dose for this group (565,000 people) would be approximately 200,000 person-rem. The peak annual dose of 18 person-rem for the Sitewide Close-In-Place Alternative would be less than a 0.01 percent increase over the estimated annual background radiation dose received by this group, while the peak annual dose of 2,000 person-rem for the No Action Alternative would contribute about 1 percent.

Table H–59 presents the time-integrated population dose over periods of 1,000 and 10,000 years. For the Sitewide Close-In-Place Alternative, the total population dose accumulated over 10,000 years (35,000 person-rem) would be less than the background dose by Sturgeon Point users in one year (203,000 person rem).

The background radiation dose to Sturgeon Point water users over 10,000 years would be an estimated 2 billion person-rem compared to the maximum projected dose of 395,000 person-rem for the No Action Alternative.

Individual Exposure to Radioactive Material

Tables H–60 and **H–61** contain the predicted peak individual TEDEs from radioactive exposure for Sturgeon Point and Niagara River, respectively.

The total peak annual TEDE for the No Action Alternative in Table H–60 (Sturgeon Point) is about a factor of 4 lower than those for the Seneca Nation of Indians receptor, and a factor of 3 lower than those for the Cattaraugus Creek receptor. The total peak annual TEDEs in Table H–61 (Niagara River) are still lower by more than a further factor of 100.

Table H–60 Peak Annual Total Effective Dose Equivalent in Millirem Per Year for the Sturgeon Point Receptor (year of peak dose in parentheses) – Loss of Institutional Controls After 100 Years

Waste Management Areas [a]	*Sitewide Close-In-Place Alternative*	*No Action Alternative*
Main Plant Process Building – WMA 1	0.0021 (200)	0.42 [b] (100)
Vitrification Facility – WMA 1	0.000011 (500)	0.078 [b] (100)
Low-Level Waste Treatment Facility – WMA 2	0.000036 (100)	0.0026 (100)
Waste Tank Farm – WMA 3	0.0012 (200)	3.0 (100) [b]
NDA – WMA 7	0.0019 (30,600) [c]	0.0018 (31,500) [c]
SDA – WMA 8	0.030 (33,700) [c]	0.030 (33,700) [c]
North Plateau Groundwater Plume	0.024 (80)	0.038 (67)
Total	0.032 (33,600)	3.6 (100)

NDA = NRC-licensed Disposal Area, SDA = State-licensed Disposal Area, WMA = Waste Management Area.

[a] For WMAs 1 through 3, the contributions to dose are presented for the key facilities that contain almost all of the radioactive materials in the WMA. However, no single facility characterizes the burial grounds, so the NDA (WMA 7) and the SDA (WMA 8) are presented as entities in their own right. Other WMAs are not sources of radioactive materials.

[b] It is assumed that maintenance actions would keep engineered systems (caps, drying systems, roofs) operational for 100 years. The doses from these units would be minimal as long as these engineered systems function as originally designed.

[c] The reason why the predicted doses are approximately the same for the Sitewide Close-In-Place and No Action Alternatives is that it is assumed that the effectiveness of any caps and other mitigating features in the Sitewide Close-In-Place Alternative degrades immediately so that groundwater flow rates and leaching rates are essentially the same for both alternatives.

Table H–61 Peak Annual Total Effective Dose Equivalent in Millirem Per Year for the Niagara River Receptor (year of peak dose in parentheses) - Loss of Institutional Controls After 100 Years

Waste Management Areas [a]	*Sitewide Close-In-Place Alternative*	*No Action Alternative*
Main Plant Process Building – WMA 1	7.5×10^{-6} (200)	1.5×10^{-3} (100) [b]
Vitrification Facility – WMA 1	4.1×10^{-8} (500)	2.8×10^{-4} (100) [b]
Low-Level Waste Treatment Facility – WMA 2	4.2×10^{-8} (100)	9.5×10^{-6} (100)
Waste Tank Farm – WMA 3	4.2×10^{-6} (200)	1.1×10^{-2} [b] (100) [b]
NDA – WMA 7	7.0×10^{-6} (30,600) [c]	6.6×10^{-6} (31,400) [c]
SDA – WMA 8	1.1×10^{-4} (33,700) [c]	1.1×10^{-4} (33,700) [c]
North Plateau Groundwater Plume	8.66×10^{-5} (80)	1.4×10^{-4} (67)
Total	1.1×10^{-4} (33,400)	1.3×10^{-2} (100)

NDA = NRC-licensed Disposal Area, SDA = State-licensed Disposal Area, WMA = Waste Management Area.

[a] For WMAs 1 through 3, the contributions to dose are presented for the key facilities that contain almost all of the radioactive materials in the WMA. However, no single facility characterizes the burial grounds, so the NDA (WMA 7) and the SDA (WMA 8) are presented as entities in their own right. Other WMAs are not sources of radioactive materials.

[b] It is assumed that maintenance actions would keep engineered systems (caps, drying systems, roofs) operational for 100 years. The doses from these units would be minimal as long as these engineered systems function as originally designed.

[c] The reason why the predicted doses are approximately the same for the Sitewide Close-In-Place and No Action Alternatives is that it is assumed that the effectiveness of any caps and other mitigating features in the Sitewide Close-In-Place Alternative degrades immediately so that groundwater flow rates and leaching rates are essentially the same for both alternatives.

Hazardous Chemical Risk

For the Niagara River and Sturgeon Point users, the peak hazard index, the peak lifetime risk, and the ratios of the concentration in water to the MCLs are all smaller than for Cattaraugus Creek or the Seneca Nation of Indians receptor and are not discussed further here.

H.2.2.4 Loss of Institutional Controls Leading to Unmitigated Erosion

Erosion is recognized as a site phenomenon and so a bounding scenario of unmitigated erosion is analyzed to estimate the dose to various receptors. For the purposes of this analysis, unmitigated erosion is defined to mean that credit is not taken for the presence of erosion control structures or performance monitoring and maintenance of any kind. Predictions of unmitigated erosion for thousands of year into the future were developed with the help of landscape evolution models that were calibrated to reproduce both historical erosion rates and current topography, starting from the topography estimated to exist after the last glacial recession. The development of the unmitigated erosion estimate is discussed in Appendix F. The chosen erosion scenario for the landscape evolution model corresponds to a case in which the site becomes partly forested and partly grassland.

The modeling below considers only erosion of the Low-Level Waste Treatment Facility on the North Plateau and of the SDA and NDA on the South Plateau. The landscape evolution model predicts very little erosion in the region of the Main Plant Process Building, Vitrification Facility, and Waste Tank Farm, and also predicts that the only places where any serious erosion would be expected in the foreseeable future would be in the vicinities of the Low-Level Waste Treatment Facility, SDA or NDA. In order to establish an upper bound on the potential impacts, the simplified single gully model described in Appendix G was used to estimate rate of soil loss for the Low-Level Waste Treatment Facility, NDA and SDA. Conservative estimates of gully advance rate (0.7 meters per year for the North Plateau and 0.4 meters per year for the South Plateau), downcutting rate (0.058 meters per year) and stable slope angle (21 degrees) were used in the analysis. The results of the analysis indicate that, for both the No Action and Sitewide Close-In-Place Alternatives, waste is completely removed from the Low-Level Waste Treatment Facility, NDA, and SDA in approximately 200, 990, and 1,900 years respectively.

A spectrum of erosion-related receptors was examined: (a) three residents,[12] one on the west bank of Erdman Brook south of the Low-Level Waste Treatment Facility, one on the east bank of Franks Creek opposite the SDA and one on the west bank of Erdman Brook opposite the NDA, each of whom would be subject to direct shine from the eroded opposite bank and would spend some time hiking about the site; (b) a resident farmer along Buttermilk Creek; and (c) the same offsite receptors evaluated for the case of continuation of institutional controls (Section 4.1.10.3.1 – Cattaraugus Creek, Seneca Nation of Indians, and Lake Erie/Niagara River Water Users).

NDA/SDA Resident/Recreational Hiker

Table H–62 presents the peak annual TEDE for the resident/recreational hiker for the Low-Level Waste Treatment Facility, NDA and SDA for each alternative if unmitigated erosion of the site were allowed to take place. The table also shows the years until peak annual dose. The assumptions governing the behavior and exposure of the recreational hiker are given in Table H–5. Exposure modes as a hiker include inadvertent ingestion of soil, inhalation of fugitive dust, and exposure to direct radiation. This receptor does not ingest radionuclides through food and water pathways.

The predicted results are quite similar for the Sitewide Close-In-Place and the No Action Alternatives. Because of conservative assumptions in the erosion model, the engineered cap only slightly reduces the rate of erosion for the Sitewide Close-In-Place Alternative. No credit is taken for stream erosion controls and no credit is taken for the erosion resistance of the rock along the side of the engineered cap. Additional detail on the erosion release model is provided in Appendix G.

Table H–62 Peak Annual Total Effective Dose Equivalent in Millirem Per Year to a Resident/Recreational Hiker on the Low-Level Waste Treatment Facility, NDA and SDA (year of peak exposure in parentheses) – Unmitigated Erosion

Waste Management Areas	*Sitewide Close-In-Place Alternative*	*No Action Alternative*
NDA – WMA 7	10 (500)	10 (325)
SDA – WMA 8	11 (375)	12 (375)
Low-Level Waste Treatment Facility – WMA 2	36 (122)	104 (100)
Total	36 (122)	104 (100)

NDA = NRC-licensed Disposal Area, SDA = State-licensed Disposal Area, WMA = Waste Management Area.

Buttermilk Creek Resident Farmer

Table H–63 presents the peak annual TEDE from the eroded Low-Level Waste Treatment Facility, NDA and SDA for the Buttermilk Creek resident farmer for the unmitigated erosion scenario. See Section H.1.3.1 for a discussion of the location of the Buttermilk Creek resident farmer. The table also shows the years until peak annual dose.

[12] The onsite resident differs from the onsite resident farmer in that the former has no garden and does not drink contaminated water. See Figure H–3 for the locations of these three receptors.

Table H–63 Peak Annual Total Effective Dose Equivalent in Millirem Per Year for the Buttermilk Creek Resident Farmer (year of peak exposure in parentheses) – Unmitigated Erosion

Waste Management Areas	*Sitewide Close-In-Place Alternative*	*No Action Alternative*
NDA – WMA 7	342 (725)	358 (650)
SDA – WMA 8	87 (625)	89 (600)
Low-Level Waste Treatment Facility – WMA 2	16 (156)	36 (103)
Total	421 (725)	443 (650)

NDA = NRC-licensed Disposal Area, SDA = State-licensed Disposal Area, WMA = Waste Management Area.
[a] Years until peak exposure in parentheses.

The relationship between the doses for the Sitewide Close-In-Place Alternative and the No Action Alternative would be much the same as for the resident/farmer. However, the predicted doses would be higher because of the greater number of exposure pathways for a resident farmer as opposed to a resident only.

Cattaraugus Creek Receptor

Table H–64 presents the peak annual TEDE from the Low-Level Waste Treatment Facility, NDA and SDA for the Cattaraugus Creek resident farmer for the unmitigated erosion scenario.

Table H–64 Peak Annual Total Effective Dose Equivalent in Millirem Per Year for the Cattaraugus Creek Receptor (year of peak exposure in parentheses) – Unmitigated Erosion

Waste Management Areas	*Sitewide Close-In-Place Alternative*	*No Action Alternative*
NDA – WMA 7	45 (725)	47 (650)
SDA – WMA 8	12 (625)	12 (600)
Low-Level Waste Treatment Facility – WMA 2	2 (156)	5 (103)
Total	56 (725)	58 (650)

NDA = NRC-licensed Disposal Area, SDA = State-licensed Disposal Area, WMA = Waste Management Area.

The doses to the Cattaraugus Creek receptor, if unmitigated erosion were allowed to progress at WNYNSC, show a similar pattern to that seen for the Buttermilk Creek intruder, but the doses would be generally lower by a factor of 5 to 10.

An illustration of how the peak annual dose to the Cattaraugus Creek receptor would vary as a function of time for the Sitewide Close-In-Place Alternative is presented in **Figure H–16**. The variation for the No Action Alternative is almost identical. The variations for the Buttermilk Creek farmer (above) and the Seneca Nation of Indians receptor (below) have the same shape, although the peaks are not of the same magnitude. The plot cuts off at about 2,000 years because all of the available radioactive material has been eroded by that time.

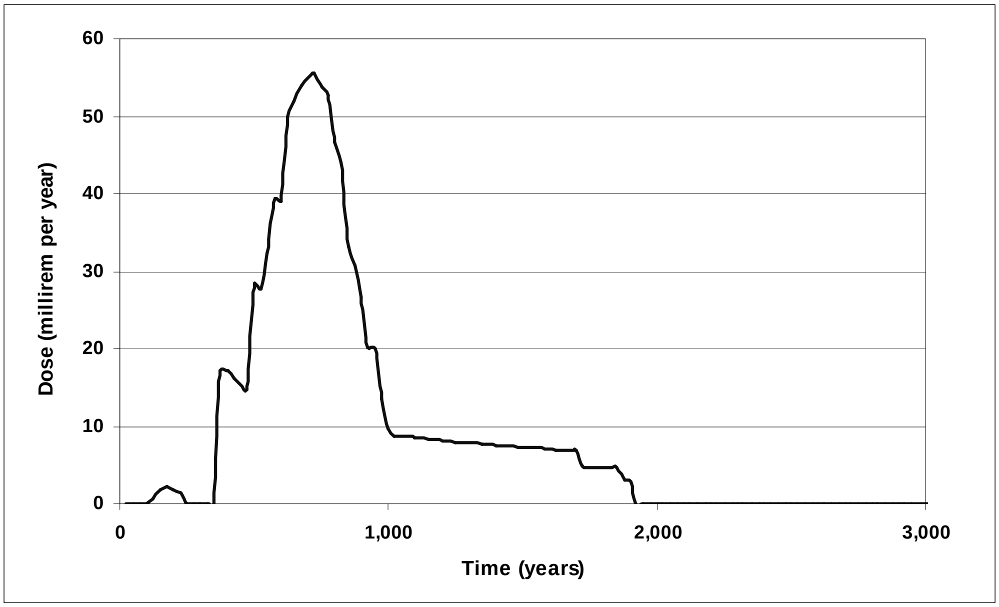

Figure H–16 Annual Total Effective Dose Equivalent (millirem per year) for the Cattaraugus Creek Receptor as a Function of Time with the Sitewide Close-In-Place Alternative and Unmitigated Erosion

Seneca Nation of Indians Receptor

A Seneca Nation of Indian receptor is postulated to use Cattaraugus Creek near Gowanda for drinking water and is also postulated to consume large quantities of fish raised in these waters. The peak annual dose for this receptor is presented in **Table H–65**.

The doses to the Seneca Nation of Indians receptor, in the event of unmitigated erosion at WNYNSC, show a similar pattern to that seen for the Cattaraugus Creek receptor, but the numerical values of the total doses would be higher by a factor of about 2 as a result of the higher assumed fish consumption.

Table H–65 Peak Annual Total Effective Dose Equivalent in Millirem Per Year to the Seneca Nation of Indians Receptor (year of peak exposure in parentheses) – Unmitigated Erosion

Waste Management Areas	*Sitewide Close-In-Place Alternative*	*No Action Alternative*
NDA – WMA 7	107 (725)	112 (650)
SDA – WMA 8	17 (625)	18 (375)
Low-Level Waste Treatment Facility – WMA 2	4 (156)	9 (103)
Total	122 (725)	129 (650)

NDA = NRC-licensed Disposal Area, SDA = State-licensed Disposal Area, WMA = Waste Management Area.

Lake Erie Water Users

In addition to the Cattaraugus Creek and Seneca Nation of Indians individuals, peak annual and time-integrated population dose estimates have been prepared for the unmitigated erosion release scenario. These are summarized in **Tables H–66** and **H–67**, respectively.

Table H–66 Peak Annual Total Effective Dose Equivalent Population Dose in Person-Rem per year to the Lake Erie Water Users (year of peak exposure in parentheses) – Unmitigated Erosion

	Sitewide Close-In-Place Alternative	*No Action Alternative*
Unmitigated Erosion	5,800 (725)	6,100 (650)

Table H–67 Time-integrated Total Effective Population Dose Equivalent in Person-Rem to the Lake Erie Water Users – Unmitigated Erosion

	Sitewide Close-In-Place Alternative	*No Action Alternative*
Integration over 1,000 years	2,200,000	2,300,000
Integration over 10,000 years	3,300,000	3,400,000

As described previously, most of this population dose would be received by the estimated 565,000 individuals using water from the Sturgeon Point intake. Using an average background dose rate of 360 millirem per year, the annual background population dose for this community would be approximately 200,000 person-rem. The peak annual population dose for the Sitewide Close-In-Place Alternative (5,800 person-rem per year) and the No Action Alternative (6,100 person-rem per year) would both be about 3 percent of the annual background dose.

Additional perspective is provided by the cumulative population dose to 1,000 and 10,000 years. For comparison, the background population dose accumulated by Sturgeon Point water users would be approximately 200 million person rem over 1,000 years and 2 billion person rem over 10,000 years. The additional population doses accumulated from WNYNSC would be relatively small.

Conclusions for Loss of Institutional Controls Leading to Unmitigated Erosion

The results for uncontrolled erosion of the SDA, NDA and Low-Level Waste Treatment Facility for the Sitewide Close-In-Place Alternative show TEDEs of up to about 36 millirem for the resident hiker, 421 millirem for the Buttermilk Creek resident farmer, 56 millirem for the Cattaraugus Creek receptor, and 122 millirem for the Seneca Nation of Indians receptor. For the two offsite receptors, these represent an increase by a factor of about 200 over the case of no erosion. The results for the No Action Alternative are only slightly higher than those for the Sitewide Close-in-Place Alternative because, under the conservative assumptions of the erosion model, the engineered safety cap only slightly reduces the rate of erosion for the Sitewide Close-In-Place Alternative.

Integrated Groundwater/Erosion Model

In the foregoing, groundwater releases and erosion releases (i.e. particulate matter washed into rivers and streams) are modeled separately. At the present time, integrated models of groundwater releases and erosion releases are beyond the state-of-the art. This question is addressed in sensitivity studies in the following section. However, as noted above, dose impacts to offsite receptors are about 200 times greater in the erosion scenarios than they are in the groundwater release scenarios. Therefore, intuitively, one would not expect the combined model to predict doses much greater than those already predicted by the stand-alone erosion model.

H.2.3 Some Observations on the Preferred Alternative

As previously discussed, it is not possible to do a long-term performance assessment for the Preferred Alternative, because the ultimate disposition of various areas of the site is not known. However, some general observations are possible.

Main Plant Process Building and Vitrification Facility – Waste Management Area 1

The plume source volume for the Main Plant Process Building and the Vitrification Facility will be completely removed. These actions most closely resemble those expected for these facilities under the Sitewide Removal alternative. Therefore, these two structures will contribute negligibly to potential health impacts under any final disposition of the site.

Low-Level Waste Treatment Facility and Lagoons – Waste Management Area 2

All facilities in WMA 2 would be removed except the permeable treatment wall, which would be periodically replaced. A hydraulic barrier wall would be installed northwest of Lagoons 1, 2, and 3 which would be removed with excavations extending 0.6 meter (2 feet) into the Lavery till. The liners and underlying berms for Lagoons 4 and 5 would be removed, as would the North Plateau Groundwater Recovery System associated with the North Plateau Groundwater Plume.

Underground lines within the excavated areas would be removed. Pipeline sections remaining at the face of the excavations would be characterized and the portion of the piping within WMA 2 removed as necessary depending on the characterization results.

These proposed actions would greatly reduce the inventory of radioactive materials and hazardous chemicals – in fact, the proposed removal of materials is greater than that proposed for the Sitewide Close-In-Place Alternative. Therefore, for groundwater releases, under any future disposition of the site, it would be expected that offsite doses and risks would be less than those already calculated for the Sitewide Close-In-Place Alternative. Dose to intruders (e.g., home constructors and well drillers) would depend on the amount of residual radioactive materials remaining after the actions described above, but would be much less than for the No Action Alternative.

Waste Tank Farms – Waste Management Area 3

The high-level radioactive waste mobilization and transfer pumps would be removed from the underground Waste Tanks. The Waste Tanks themselves would remain in place, as would the Permanent Ventilation System Building, STS Support Building, and underground piping in the area. The STS vessels and contents in Tank 8D-1 will remain in place. The Equipment Shelter and Condensers and Con-Ed Building would be removed. The Waste Tanks would continue to be monitored and maintained with the Tank and Vault Drying System operating as necessary. The piping used to convey high-level radioactive waste in the High-Level Waste Transfer Trench would be removed and the trench would remain in place. Pipe removal would be conducted with soil removal with cutoffs of the piping occurring somewhere between the excavation and the tanks. The barrier wall would also extend westward across the piping runs.

If no further action were taken, this would be similar to the No Action Alternative. It would allow future selection of complete removal, Sitewide Close-in-Place, or No Action. Therefore, the range of health impacts already calculated for this WMA spans the possible range from future disposition possibilities for the Waste Tank Farm.

NDA – Waste Management Area 7 and SDA – Waste Management Area 8

The NDA and SDA would continue as at present, under monitoring and/or active management. Therefore the future possibilities include any of removal per the Sitewide Removal Alternative, Sitewide Close-In-Place, or No Action. Calculations already performed span the potential range of health impacts.

North Plateau Groundwater Plume

The source area of the North Plateau Groundwater Plume would be removed as in the Sitewide Removal Alternative. The nonsource area of the North Plateau Groundwater Plume would be contained by the permeable reactive barrier and permeable treatment wall installed for the Interim End State as in the No Action Alternative. The permeable treatment wall would require replacement on a periodic basis. The future possibilities include any of removal per the Sitewide Removal Alternative, Sitewide Close-In-Place, or No Action. Calculations already performed span the range of possible health impacts.

Cesium Prong

The cesium prong would be managed by continuing restrictions on use and access, exactly as for both the No Action and Sitewide Close-In-Place Alternatives.

Conclusion – Preferred Alternative

Initial decommissioning actions for this alternative would essentially remove the Main Plant Process Building, the Vitrification Facility, and the source for the North Plateau Groundwater Plume as potential sources of health impacts. The potential impact of the Low-Level Waste Treatment facility would be much reduced. Potential health impacts of the Waste Tank Farm, the NDA, the SDA, the non-source portion of the North Plateau Groundwater Plume, and the Cesium Prong span the ranges already calculated in the Sitewide Removal, the Sitewide Close-In-Place, and the No Action Alternatives.

H.3 Sensitivity Analysis

Estimation of human health impacts depends in a complex manner on geologic and environmental conditions, facility closure designs, the structure of models used to represent these conditions and features and the values of parameters used in the models to characterize the conditions and features. These conditions and features may not be well known or have variability over space and time that contributes to uncertainty in estimates of health impacts. In this section, deterministic sensitivity analysis is used to provide insight into the potential range of uncertainty in estimates of health impacts. Key conditions or parameters selected for sensitivity analysis include: amount of precipitation (wetter or dryer conditions), degree of degradation of engineered caps, ability to retain technetium in grout, rate of advance and downcutting of a single large gully, the impact of erosion on engineered structures designed to limit release to groundwater transport pathways, and the degree of degradation of the slurry wall on the North Plateau. The sensitivity analysis cases use the Sitewide Close-In-Place Alternative as the primary example but provide information relevant to all EIS alternatives.

H.3.1 Amount of Precipitation

Water reaching the ground surface as precipitation enters into estimation of human health impacts for both groundwater and erosion release scenarios. Precipitation infiltrating the ground surface influences rate of groundwater movement while run-off produced by precipitation influences rate of erosion. Rate of flow of creeks affects concentration of contaminants in the creek due to a given release and thereby influences estimates of health impacts. Available data characterizing the variability include annual rate of precipitation at Jamestown, NY reported by the National Climatic Data Center (NCDC 2008) for 28 years between calendar years 1979 and 2006 and annual average flow of Cattaraugus Creek at Gowanda, NY reported by the U.S. Geological Survey (USGS 2008) for 64 years between calendar years 1941 and 2006. Annual precipitation varied between 0.89 and 1.41 meters with and average of 1.13 meters. Ten percent of years had precipitation greater than 1.23 meters while ten percent of years had precipitation less than 0.98 meters. A similar range of moderate variability is found in the flow rate data for Cattaraugus Creek. Ten percent of years had annual flow less than 16.5 meters per second while ten per cent of years had annual flow greater than

26.3 meters per second with an annual average of 21.2 meters per second. The minimum and the maximum annual flows for the period of record were 15.1 and 29.2 meters per second, respectively.

Three-dimensional near-field groundwater flow models for both the North and South Plateaus for the Sitewide Close-In-Place Alternative are described in Appendix E of the EIS. Features of these models relevant for evaluation of the importance of variability of precipitation are presence of a slurry wall on the North Plateau that limits flow through the system and the low rate of infiltration predicted for the South Plateau due to low hydraulic conductivity of geohydrologic units in that location. For the North Plateau, the predicted rate of infiltration consistent with function of a degraded slurry wall is less than ten percent of the lowest value of precipitation reported for the period of record (see Table H–73). As a consequence of this condition, the rate of movement of groundwater and related rate of release of contaminants from the Main Plant Process Building and the Waste Tank Farm would not change greatly with variation in rate of precipitation. A similar situation would occur on the South Plateau where recharge is a small percentage of the lowest rate of precipitation reported for the period of record. For erosion scenarios, variation in rate of precipitation is implicitly incorporated into calibration of the landscape evolution model over a long period of time.

For the health impact models used in the EIS, variation in annual rate of flow of creeks produces an inverse but proportionate variation in estimate of impact. This behavior applies for both groundwater and erosion release scenarios. Thus, for only ten percent of years the estimates of impacts would be more that twenty-five percent higher than that reported for average conditions.

H.3.2 Degree of Degradation of Engineered Caps

For the Sitewide Close-In-Place Alternative, the Main Plant Process Building, the Low-Level Waste Treatment Facility, the Waste Tank Farm, the NDA and the SDA are located under engineered caps. The primary design features limiting infiltration of each cap are a gravel drainage layer and an underlying layer of clay. Additional layers that are not considered in the EIS infiltration model are geotextiles and soil that function to protect and support the major functional layers. More detailed description of the engineered caps is presented in Appendix C of the EIS. With respect to control of infiltration, the EIS model simulates diversion of water through the drainage layer and impedance of downward flow of water through the clay layer. The design values of hydraulic conductivity for the drainage and clay layers are 3.0 and 5×10^{-9} centimeters per second, respectively. The response of rate of infiltration through the cap to variation in these principal parameters was simulated using a two-dimensional representation implemented with the Subsurface Over Multiple Phases (STOMP) computer code. Results of this analysis are presented in **Table H–68**. As would be expected, the rate of infiltration increases in proportion to increase in hydraulic conductivity of the clay layer but increases in a non-linear manner as hydraulic conductivity of the drainage layer decreases.

Table H–68 Dependence of Infiltration through an Engineered Cap on Values of Hydraulic Parameters

Hydraulic Conductivity of the Drainage Layer (centimeters per second)	*Infiltration Rate (centimeters per year)*		
	Hydraulic Conductivity of the Clay Layer (centimeters per second)		
	5×10^{-9}	5×10^{-8}	5×10^{-7}
3.0	0.015	0.15	1.44
0.03	0.11	1.12	10.3
0.003	0.31	3.02	24.6

For the rubble pile, Liquid Waste Cell and General Purpose Cell of the Main Plant Process Building and the Vitrification Cell, the rate of movement through the contaminated material is equal to the rate of infiltration through the cap and estimates of health impacts would increase in proportion to this rate of infiltration. For the Waste Tank Farm, the rate of downward movement through the tanks is determined by the rate of downward movement through the unweathered Lavery till and would not increase in response to increase in infiltration through the cap. Thus, a minor dependence of estimate of dose on amount of precipitation is expected at the Waste Tank Farm.

H.3.3 Retention of Technetium

Analysis of base cases for groundwater release scenarios for tanks 8D-1 and 8D-2 of the Waste Tank Farm identified technetium-99 as a major contributor to human health impacts. Grouts designed for stabilization of the tanks include fly ash material that is expected to reduce the valence state of technetium producing a precipitate with low solubility as well as sorbents designed to retain radionuclides by physical and chemical bonding. The EIS release models do not simulate solubility release but relate rate of release to degree of partitioning between the liquid and solid phases of the waste form. For technetium, a conservative value of 1.0 milliliters per gram, consistent with retention on a natural clay material (Sheppard and Thibault 1990), has been adopted as the value of distribution coefficient for the base case. A plausible lower bound value of distribution coefficient for technetium in the waste form is the value of 0.1 milliliters per gram reported for sand in natural deposits (Sheppard and Thibault 1990). A plausible higher value is that recommended for surface soil in analysis of decommissioning scenarios, 7.4 milliliters per gram (Beyeler et al. 1999). Estimates of impact for a resident farmer receptor for releases from Tank 8D-1 are presented in **Table H–69**. The results show a strong dependence on the value of distribution coefficient for technetium. For the lower values of distribution coefficient of technetium, technetium-99 is the radionuclide dominating dose and the year of peak impact occurs within approximately 100 years. For the higher value of technetium distribution coefficient, isotopes of uranium dominate impacts, impacts occur in the distant future and peak dose due to technetium-99 peak is approximately 25 millirem per year after approximately 170 years.

Table H–69 Dependence of Onsite Resident Farmer Peak Annual Dose on the Value of Technetium Distribution Coefficient for Groundwater Release from Tank 8D-1

Distribution Coefficient of Technetium in Grout (milliliters per gram)	*Peak Annual Dose (millirem per year)*			*Years to Peak Dose*
	Drinking Water	*Garden*	*Total*	
0.1	609	274	883	28
1.0	78	145	223	116
7.4	104	10	114	1,200

H.3.4 Rate of Gully Erosion

The landscape evolution models described in Appendix F were calibrated to current conditions of the Buttermilk Creek watershed and predict low rates of erosion of plateau areas of the site near the project waste management areas. Estimates of rate of soil loss for a single large gully were used to develop estimates of human health impact. These results were developed using conservative estimates of stable slope angle (21 degrees), rate of advance (0.4 meters per year) and downcutting (0.058 meters per year) described in Appendix F that were assumed to occur for the entire period of analysis. The analysis did not take credit for the presence of erosion control structures or the performance of maintenance. Field surveys of gully behavior report an initial period of rapid growth followed by decrease in rate of growth, attainment of a maximum length and transition into an inactive state (Nachtergaele et al. 2002). The length, surface area and volume were reported to follow a negative exponential relation termed Graf's Law:

$$L_t = (L_f - L_0) \{ 1 - \exp [-b(t - t_0)] \} \qquad (H\text{-}2)$$

Where:

L_t = length of gully at time t, meters,
L_f = final equilibrium length of gully, meters,
L_0 = length of gully at initial time, meters,
t = time, years,
t_0 = initial time, years, and
b = rate parameter, 1/years.

The sensitivity of estimates of health impacts to the gully growth model were investigated using this relation. The hulls portion of the NDA was used as the case for this analysis. For this area, the distance between Erdman Brook, a reasonable candidate initiation point for the gully, and Franks Creek is approximately four hundred meters and the disposal area is approximately 150 meters from Erdman Brook. Assuming a maximum gully length of four hundred meters and an initial growth rate of 0.4 meters per year, the value of the parameter b in Equation H-2 is estimated as 0.001 per year. Using this value and applying Equation H-2 provides estimates of the time dependent rate of advance for use in the single gully erosion model. The value of stable angle of 21 degrees was retained for the sensitivity analysis but the rate of average downcutting of Buttermilk Creek consistent with the landscape evolution modeling of 0.018 meters per year was applied for the rate of downcutting of the gully. Results for this sensitivity analysis and the base case are summarized in **Table H–70**. The results indicate that the assumption of constant rate of downcutting of the gully provides conservatism in estimate of dose as large as a factor of approximately four.

Table H–70 Dependence of Single NRC-licensed Disposal Area Gully Impacts on Model Parameters

Parameter	*Value*	
	Base Case	*Sensitivity Case*
Time to Reach Top of Waste (years)	490	910
Time to Reach Bottom of Waste (years)	955	2,330
Time to Peak Dose (years)	717	2,330
Peal Dose (millirem per year)	170	45

H.3.5 Erosion Damage of Groundwater Flow Barriers

The near-field groundwater flow models described in Appendix E are used as a basis for estimation of human health impacts for groundwater release scenarios. In these analyses, the engineered barriers are assumed to degrade due to natural processes, such as, clogging of gravel in drainage layers and dessication of clay in slurry walls but to remain unaffected by erosion processes. The potential influence of erosion damage on estimates of dose is considered in this section through introduction of segments of elevated hydraulic conductivity in the upgradient slurry wall of the Sitewide Close-In-Place Alternative. In the two cases considered, separate twenty-meter high hydraulic conductivity segments of the slurry wall were placed in the vicinity of the Waste Tank Farm and the General Purpose Call of the Main Plant Process Building.

In the first case, damage to the slurry wall in the vicinity of the Waste Tank Farm, Tank 8D-1 was selected as the example case and the near-field flow model predicts increased rate of flow into the tank excavation, increased horizontal flow through the tank but limited increase of vertical flow through the tank itself. Results of the flow analysis are summarized in **Table H–71** while results of the dose analysis for a resident farmer receptor located on the North Plateau 100 meters downgradient of the tank are presented in **Table H–72**. Estimates of dose were developed for both horizontal and vertical flow through the tank and the contribution of the horizontal flow was a small fraction of the contribution from vertical flow.

Table H–71 Summary of Flow Conditions for Waste Tank Farm Slurry Wall Sensitivity Analysis

Condition	*Case*	
	No Erosion Damage to Slurry Wall	*Erosion Damage to Slurry Wall*
Rate of Groundwater flow into the Excavation (cubic meters per year)	963	1,622
Interstitial Velocity (meters per year)		
Vertical	0.132	0.137
Horizontal	0	0.153

Table H–72 Summary of Peak Annual Dose Estimates for Waste Tank Farm Slurry Wall Sensitivity Analysis

Condition	*Peak Annual Dose (millirem per year)*	
	Drinking Water	*Garden*
No Erosion Damage to Slurry Wall	78	145
Erosion Damage to Slurry Wall	119	149

For the case of damage to the slurry wall in the vicinity of the General Purpose Cell, interstitial velocity through the cell into the underlying slack-water sequence increases from 0.158 meters per year for the base case to 0.566 meters per year. The estimate of dose for a resident farmer receptor located on the North Plateau downgradient of the Main Plant Process Building due to releases from the General Purpose Cell increases from 188 millirem per year at year 100 for the base case with a degraded slurry wall to 6,960 millirem per year at year 180 for the case of damage to the slurry wall. Thus, the results indicate that local hydrologic conditions contribute to dependence of estimates of dose for below grade cells of the Main Plant Process Building on integrity of the slurry wall. Local damage to this hydraulic barrier could have a major impact on the amount of groundwater moving through the cells leading to the predicted strong sensitivity of the estimate of dose. Should the Sitewide Close-In-Place Alternative be chosen, it would be appropriate to consider the implications of this finding when designing groundwater flow barriers.

H.3.6 Degree of Degradation of Slurry Walls

For the Sitewide Close-In-Place Alternative, slurry walls are used on both the North and South Plateaus to limit the amount of groundwater reaching sub-surface waste. Because of greater offset in value of hydraulic conductivity between the slurry wall and the surrounding natural materials on the North Plateau than on the South Plateau, the slurry wall is more important to reduction of dose for facilities on the North Plateau. The closure design for the Main Plant Process Building and Waste Tank Farm on the North Plateau includes a circumferential slurry wall and additional slurry walls up- and downgradient of the circumferential slurry wall. The near-field flow model for the North Plateau includes only the upgradient slurry wall and analysis presented in this section investigates the sensitivity of estimates of dose for the General Purpose Cell of the Main Plant Process Building to variation in the value of hydraulic conductivity of this slurry wall.

For the base case for this EIS, the value of the hydraulic conductivity of the slurry wall for the long-term period is taken as 1×10^{-6} centimeters per second, two orders of magnitude greater than the design value of 1×10^{-8} centimeters per second. For comparison purposes, the average value of hydraulic conductivity of the thick-bedded unit intersected by the slurry wall is 2.5×10^{-3} centimeters per second. For this sensitivity analysis, the hydraulic conductivity of the slurry wall is increased by one order of magnitude in a first case and by an additional order of magnitude in a second case.

The analysis proceeds in two steps: the three-dimensional near-field groundwater model is used to establish the distribution of hydraulic head and groundwater flow velocities in the first step while the integrated dose model uses the results of the first step to estimate human health impacts in the second step. Because data are not available to calibrate conditions for the first step, infiltration rates upgradient of the slurry wall are iteratively varied to produce a water table near the ground surface at the slurry wall. For the base and sensitivity cases, total infiltration immediately upgradient of the slurry wall and the flow balance around the General Purpose Cell are summarized in **Tables H–73 and H–74**, respectively. Doses estimated for the base, first sensitivity and second sensitivity cases are 220, 285 and 11,090 millirem per year, respectively. The large difference in estimate of dose is related to a change in flow regime indicated in the flow estimates presented in Tables H–68 and H–69. The General Purpose Cell extends from the ground surface downward toward the underlying Slackwater Sequence and with an effective slurry wall the primary flow is low and in the vertical direction. For the case of less than a two order of magnitude difference in hydraulic conductivity between the slurry wall and thick-bedded unit, the flow direction transitions to horizontal and flow rate approaches the value estimated for the location in the absence of the slurry wall.

Table H–73 Predicted Conditions for the North Plateau Three-dimensional Near-field Groundwater Flow Model, Slurry Wall Sensitivity Analysis

Case	*Hydraulic Conductivity of the Slurry Wall (centimeters per second)*	*Rate of Infiltration Upgradient of the Slurry Wall*		*Average Linear Velocity in the Slackwater Sequence (meters per year)*
		Volumetric (cubic meters per year)	*Flux (centimeters per year)*	
Base	1×10^{-6}	3,314	0.07	97
First Sensitivity	1×10^{-5}	4,059	0.09	103
Second Sensitivity	1×10^{-4}	10,537	0.22	131

Table H–74 Flow Balance for the General Purpose Cell, Slurry Wall Sensitivity Analysis

Direction	*Volumetric Flow Rate (cubic meters per year)*		
	Base Case	*First Sensitivity Case*	*Second Sensitivity Case*
Inflow			
Top	5.933	5.933	5.933
South	8.539	14.032	215.88
East	0.017	0.017	59.153
Outflow			
Bottom	14.246	19.691	24.615
North	0.235	0.283	255.03
West	0.007	0.007	1.355

H.4 References

Atkinson, A. and J. A. Hearne, 1984, *An Assessment of the Long-Term Durability of Concrete in Radioactive Waste Repositories*, AERE-R11465, United Kingdom Atomic Energy Authority, Harwell, Oxfordshire, UK, October.

Beyeler, W. E., W. A. Hareland, F. A. Duran, T. J. Brown, E. Kalinina, D. P. Gallegos, and P. A. Davis, 1999, *Residual Radioactivity from Decommissioning*, *Parameter Analysis*, NUREG/CR-5512, Vol. 3, Sandia National Laboratories, Albuquerque, New Mexico, October.

Bradbury, M. H., and F. A. Sarott, 1995, *Sorption Databases for the Cementitious Near-Field of a L/ILW Repository for Performance Assessment*, PSI Bericht No 95-06, Paul Scherrer Institute, Switzerland, March.

Clifton, J. R., and L. I Knab, 1989, *Service Life of Concrete*, NUREG/CR-5466, U.S. Nuclear Regulatory Commission, Washington, DC, November.

Dames and Moore, 1995a, *Testing and Characterization of Glacial Deposits: Geochemical and Radionuclide Adsorption Data*, Project 10805-953-8251, West Valley Demonstration Project, Orchard Park, New York, June 26.

Dames and Moore, 1995b, *Investigation of Strontium Behavior in the Surficial Sand and Gravel-Groundwater System*, Project 10805-953-8251, Orchard Park, New York, June 9.

DOE (U.S. Department of Energy), 1999, *Radioactive Waste Management Manual*, DOE M 435.1-1, Washington, DC, July 9.

EPA (U.S. Environmental Protection Agency), 1999, *Exposure Factors Handbook*, EPA/600/C-99/001, Washington, DC, February.

Krejzler, J. and J. Narbutt, Nukleonika, 2003: 48 (4):171-175.

Lonin, A. Y., and A. P. Krasnopyorova, 2004, Problems of Atomic Science and Technology, No 5, 82-84.

Meyer, P. D., and G. W. Gee, 1999, *Information on Hydrologic Conceptual Models, Parameters, Uncertainty Analysis, and Data Sources for Dose Assessment at Decommissioning Sites*, NUREG/CR-6656, Pacific Northwest National Laboratory, Richland, Washington, November.

Nachtergaele, J., J. Poesen, D. Oostwould Wijdenes, and L. Vandekerckhove, 2002, Geomorphology, 46, pp. 223-239.

NCDC (National Climatic Data Center), 2008, http://www1.ncdc.noaa.gov/pub/orders/49835014431inv.txt.

Oztunali, O. I., and G. W. Roles, 1986, *Update of Part 61 Impacts Analysis Methodology*, NUREG/CR-4370, Environsphere Co., New York, New York, January.

Rowe, R. K., R. M. Quigley, R. W. I. Brachman, and J. R. Booker, 2004, Barrier Systems for Waste Disposal Facilities, Spon Press, New York, New York.

Sheppard, M. I., and D. H. Thibault, 1990, "Default Soil Solid/Liquid Partition Coefficients, K_dS, For Four Major Soil Types: A Compendium", *Health Physics*, 59, No 4, October, pp. 471-482.

State of Missouri, 2004, *White-Tailed Deer,* http://www.conservation.state.mo.us/nathis/mammals/deer2/, July 9.

State of North Carolina, 2004, *The White-Tailed Deer*, http://www.carolina.com/redwolf/animals/deer.asp, July 9.

Stinton, D. P., E. W. McDaniel, and O. Weeren, 1984, Material Research Society Symposium, Volume 26 (1984), Elsevier Science Publishing Co, Inc, New York, New York.

USGS (U.S. Geological Survey), 2008, USGS Annual Statistics for New York, http://waterdata.usgs.gov/ny/nwis/annual//referred_module= sw&site_no=042135007por0.

WVNS (West Valley Nuclear Services Company), 1993a, *Environmental Information Document, Vol. III, Hydrology: Part 3 of 5, Erosion and Mass Wasting Processes,* WVDP-EIS-009, Rev. 0, West Valley, New York, January.

WVNS (West Valley Nuclear Services Company), 1993b, *Environmental Information Document, Vol. III, Hydrology, Part 4 of 5, Groundwater Hydrology and Geochemistry*, WVDP-EIS-009, Rev. 0, West Valley, New York, February.

WVNS (West Valley Nuclear Services Company), 1993c, *Environmental Information Document, Vol. III, Hydrology: Part 5 of 5, Vadose Zone Hydrology*, WVDP-EIS-009, Rev. 0, West Valley, New York, February.

WVNS (West Valley Nuclear Services Company), 1993d, *Environmental Information Document, Vol. I, Geology,* WVDP-EIS-004, Rev. 0, West Valley, New York, March.

WVNS (West Valley Nuclear Services Company), 1993e, *Environmental Information Document, Vol. VIII, Air Resources: Part 2, Meteorology,* WVDP-EIS-015, Rev. 0, West Valley, New York, December.

Yu, C., A. J. Zielen, J. J. Cheng, Y. C. Yuan, L. G. Jones, D. J. LePoire, Y. Y. Wang, C. O. Loureiro, E. Gnanapragasam, E. Faillace, A. Wallo III, W. A. Williams, and H. Peterson, 1993, *Manual for Implementing Residual Radioactive Material Guidelines Using RESRAD, Version 5.0*, ANL/EAD/LD-2, Argonne National Laboratory, Argonne, Illinois, September.